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13. ABSTRACT (Maximum 200 words)

The goal of the program was the demonstration of the feasibility of a compact hydrogen maser by use of a high temperature superconductor (HTS)-based cavity. The cavity was of the "lumped element" type, with dimensions about 1/4 those of the TE_{01} cylindrical cavity normally used. A coating of HTS on the cavity electrodes was used to increase the Q from about 5,000 for copper to a value over 25,000 for which masing would occur. The maser was design and fabricated, overcoming a number of difficult problems, most of which were associated with operation at cryogenic temperatures. Limitations on resources prevented significant testing. However, given the difficulties discovered during the design and fabrication, it was determined that the commercial viability of the compact maser was doubtful, and no further effort toward development was anticipated. The program was very useful in enhancing the maser-related technology base at Physical Sciences Inc. (PSI). This technology has been directly applied to the development of a novel rubidium maser that is expected to have a strong commercial market.

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Final Report
COMPACT HYDROGEN MASER WITH A HIGH TEMPERATURE SUPERCONDUCTOR-BASED CAVITY

Contract No. F49620-93-C-0060

SBIR PHASE II Program Plan

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February 1996

Objectives

The objective of the program was to determine the feasibility of a hydrogen maser in which the cavity is dramatically smaller than the TE_{011} cavity normally used. This was to be accomplished using a loop-gap resonator. Such a resonator is satisfactory in all aspects except that the quality factor, Q, would be too low for the device to operate in the active mode, *i.e.*, as maser. This problem was to be avoided by coating the cavity electrodes with YBCO, a high temperature superconductor (HTS). The use of the HTS was expected to restore the cavity Q to about 30,000, a value at which the maser would self-oscillate.

The tasks to meet this objective were as follows:

Task 1. We will complete the final design of the resonator and cryostat. The basic design was completed in Phase I, with only the construction details to be resolved.

Task 2. Construction of the cryostat and copper maser resonator will be performed during this task. The temperate control circuits, and configuring the maser for passive mode measurement also will be included.

Task 3. The construction and characterization of the superconducting cavity will be performed simultaneously with Task 2. The copper resonator and the superconducting resonator will have identical geometries.

Task 4. We will use a vector impedance method for the passive measurement of the maser. This method offers greater accuracy of measurement and compensation for cavity pulling.

Task 5. The measurement and evaluation of the maser will include the maser stability measurements as well as characterization of the hydrogen interactions with the teflon.

Task 6. A commercially relevant design will be produced that reflects the maser requirements determined during the completion of the first five tasks.

Status

After one year of the contractual effort, Task 1 and a portion of Task 2 were accomplished. For Task 2, the (copper) cavity was constructed, and its resonant frequency and Q measured. The C field coil was fabricated, and the field profile measured. The maser, with the original cavity, was tested to insure operation of the electronics, including the hydrogen state selector. It operated acceptably, although there were indications that the magnetic shields required re-annealing. The annealing was redone. Finally, a number of difficult design issues were addressed, including the details of the tuning mechanism for the cavity. The year concluded with an essentially complete detailed mechanical design for the maser.

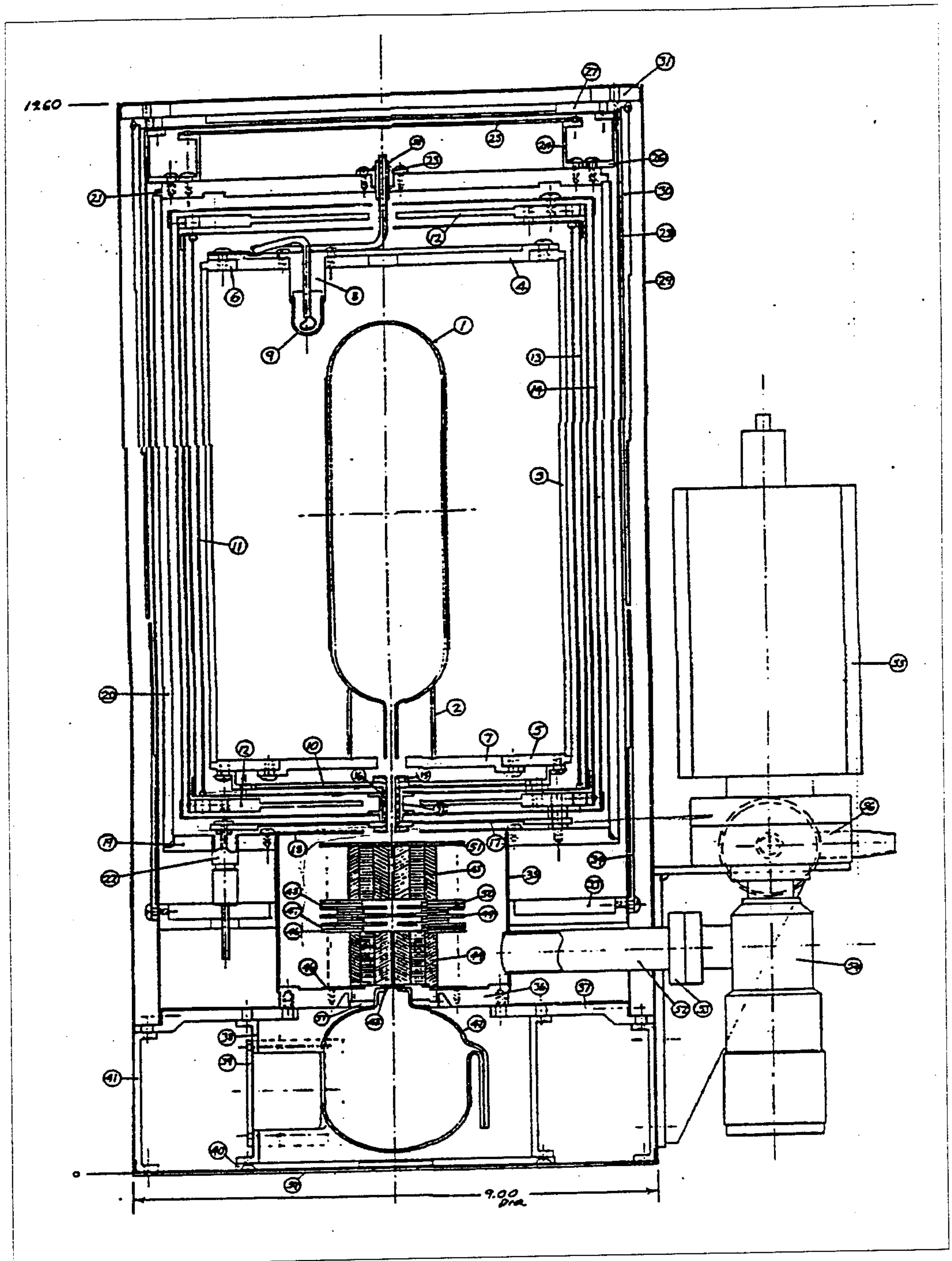

Figure 2. Schematic of the original Sigma Tau AF-1 maser used as the test vehicle for the program.

This significantly slowed the design process, and required more resources than anticipated. Issues of the design are discussed below in detail. For reference, the entire design of the physics package is shown in Figure 3. In summary, and from the center outward, the package consists of the hydrogen containment bulb, the cavity electrodes, the cavity shell (which is also a vacuum shell), the liquid nitrogen vessel, the high vacuum chamber (in common with the bulb vacuum), and the thermal isolation vacuum chamber. Included in the design are magnetic and thermal shields not shown in this drawing.

Results

Summary

All of the components have been designed. Most of the components for the maser have been fabricated, and sub-assemblies completed. The system has been checked for vacuum integrity. The cavity resonant frequency has been measured, in preparation for final machining and shimming.

Much of the effort during the second half of the program was directed toward the solution of numerous difficult problems encountered in realizing the maser within the significant constraints produced by cryogenic operation as well as those usually associated with masers used for precision time interval measurement. Most of these problems were solved, and their solutions are documented here.

Consideration was given of using superconducting magnetic shields. These shields were expected to be much more effective than conventional mu-metal ones. A paper documenting these shields is appended. However, after an initial investigation, it was decided that use of superconducting shields would entail an inordinate effort, and that conventional shields would be used.

Maser Design

Approach

The design of this maser was based on the previous work on developing compact hydrogen masers. The TE_{011} microwave cavity was the largest element in the maser and was the focus of the miniaturization effort. The microwave resonator developed in the cited work was the so-called loop-gap resonator, shown in Figure 1, 14. This resonator is a lumped element resonant structure tuned to the hydrogen hyperfine transition frequency and can be made much smaller than the wavelength dependent TE_{011} microwave cavity. An unfortunate result of using a compact resonator is a significant reduction in cavity Q, which is a measure of the resonant microwave energy storage. The maser resonator tested in this maser was a cryogenic superconducting maser that had a resonator Q that is significantly higher than its copper counterpart and was high enough to enable improved passive or active maser operation in a compact construction.

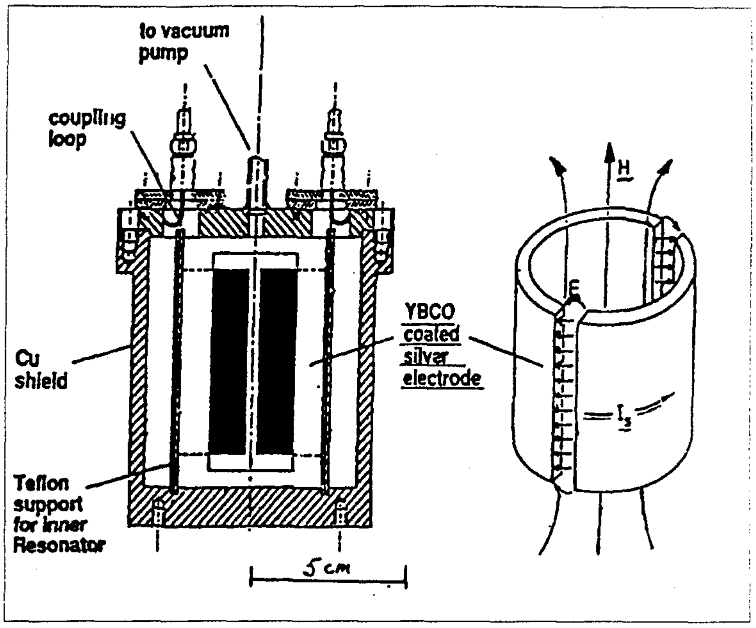

Figure 1. Schematic of the loop-gap resonator.

A complete maser consists of many elements other than the cavity, and to develop the entire system would be far beyond the scope of the Phase II. To avoid this difficulty, we used an existing hydrogen maser, the Sigma Tau AF-1. While this maser was constructed in 1981, it had not functioned well, and was therefore available for use as a test bed. This maser is shown in Figure 2. The intent was to replace the existing cavity and bulb with the loop gap resonator and an appropriate bulb, but retain almost all of the other elements, including the hydrogen source, state selector and optics, c-field coil supply, and the RF receiver. In this manner, we reduced the necessary engineering and design to a manageble level.

It is noted, however, that the use of the AF-1 imposed a significant constraint on the size of the new physics package. Although the AF-1 used a TE_{011} cavity, it had been made smaller than usual by loading it with dielectric. In other words, it was already a "compact" cavity. Early in the design phase, it became clear that fitting the PSI package, complete with cryogenics, into the available space was a challenge - one that required a number of carefully thought-out engineering solutions.

Issues

The issues involved in the design of the new physics package were the following:

Vacuum

- new electrical feedthroughs designed for cryogenic operation
- cryogenic liquid feedthroughs

Cryogenics

- LN_2 versus refrigeration
- mechanical supports and alignment
- RF cabling
- temperature control at several temperatures

Tuning of Superconducting Cavity

Magnetics

Solutions

Vacuum

• new electrical feedthroughs designed for cryogenic operation: The AF-1 maser was designed to operate in the active mode only. Thus, there was only one RF connection to the cavity. While, eventually, the new maser would also operate in the active mode, initial measurements could most easily be made in the passive mode. This required that there be two rf ports.

Feedthroughs for UHV at cryogenic temperatures are intrinsically more difficult than those at room temperature. Few connectors are designed to remain tight over a wide temperature range, particularly coaxial feedthroughs that were small enough to fit within the tight confines of the package. A solution was found in Microdot™ connectors, brazed into special flanges which were sealed to the cavity using indium "O" rings.

• cryogenic liquid feedthroughs: To feed liquid nitrogen into the system, a thin wall steel tube with a bellows for strain relief was used.

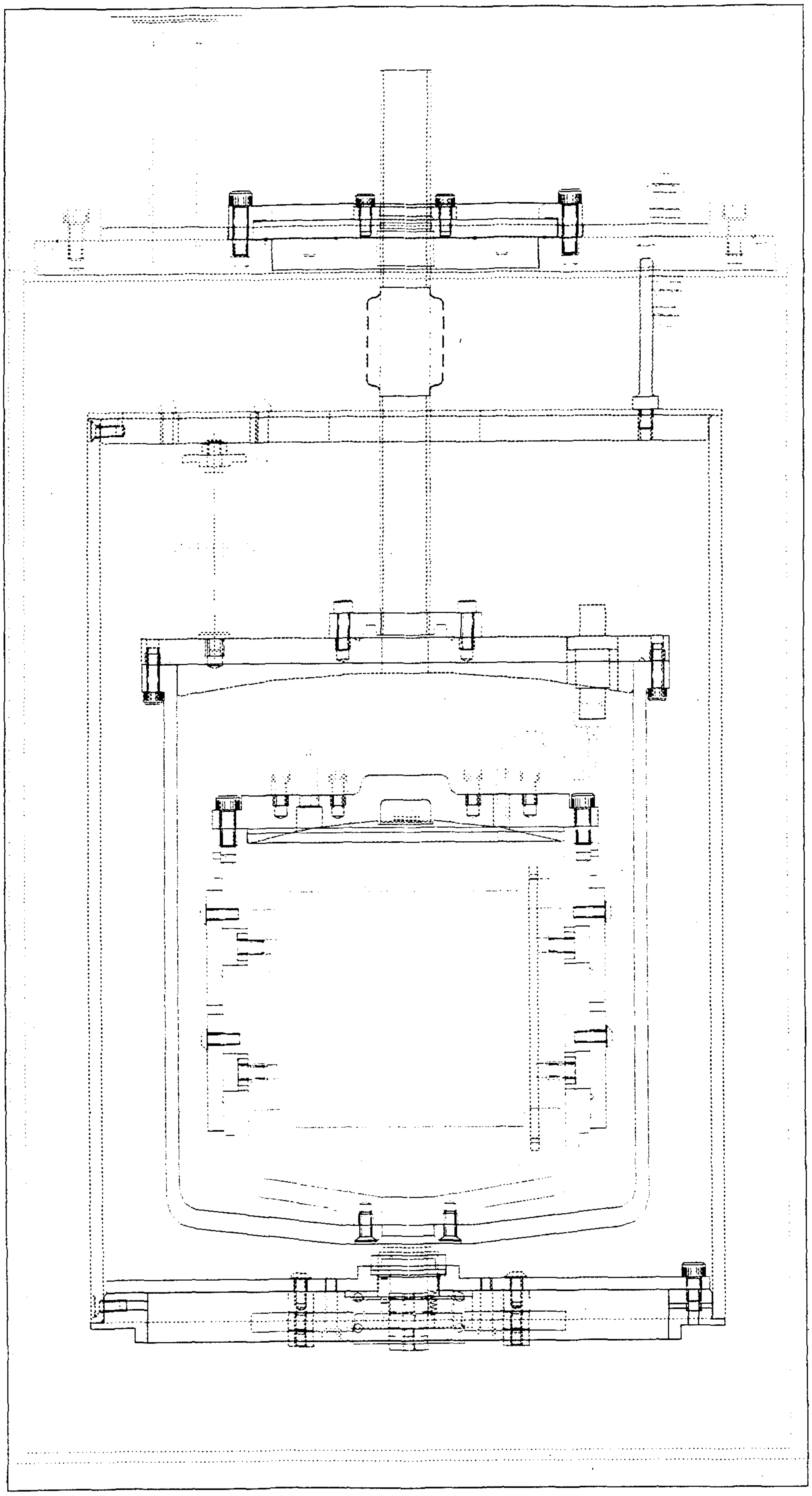

Figure 3. Drawing of the maser with the compact cavity.

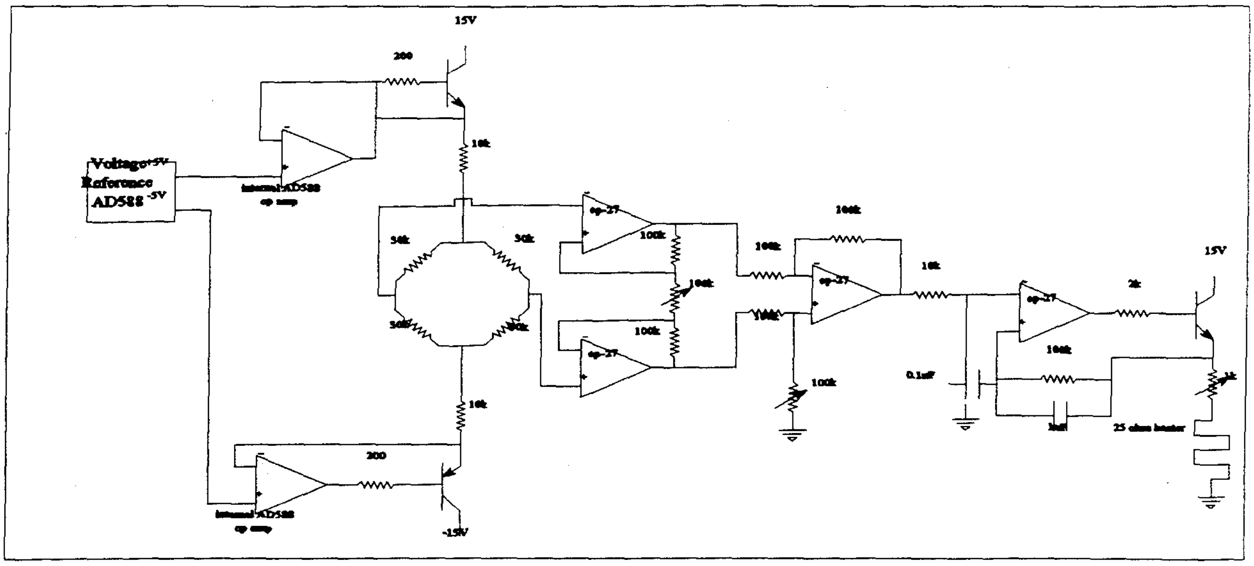

Figure 6. Schematic of the temperature control circuit.

In order to utilize the hydrogen source and state selector and its optics, the new cavity had to have the storage bulb aperture located in the same position as the original bulb. It was not necessary to maintain this bulb stem aperture at cryogenic temperatures. Nor would it be particularly easy to do so, since it was not possible to avoid the radiative heating of the section of the bulb and the resonator volume that is in line with the hydrogen source. Fortunately, the quartz bulb has a very low coefficient of thermal conductivity, and thus, if supported only by the neck at the aperture, would be very poorly coupled to the cavity. Any additional radiative heating was avoided with several heat shields.

Tuning of Superconducting Cavity

The maser resonator was intrinsically difficult to tune. Rough tuning of the resonant structure was performed by increasing the size of the capacitive gap between the electrode sections, as shown in Figure 7. However, once the maser is tuned at room temperature and then cooled to liquid nitrogen temperatures, the thermal contraction of the cavity will cause strong detuning of the resonant structure.

The frequency of the resonator decreases as the gap size is reduced. This phenomenon has been studied and documented. When the resonator is tested with copper electrodes, the outer shield-can contracts at the same rate as the electrodes. These effects partially cancel. However, stainless steel has a lower thermal expansion coefficient than copper.

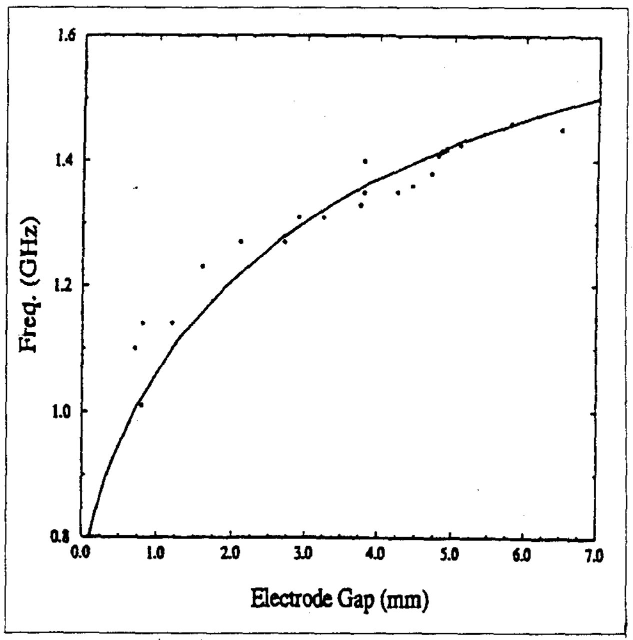

Figure 7. Resonant frequency as a function of the gap in the loop-gap resonator.

Cryogenics

• LN_2 versus refrigeration: The original intent was to operate the maser with either liquid nitrogen or mechanical cooling. After examining the design in detail, it was determined that the cryocooler would add too much to the complexity to warrent its inclusion in this experimental vehicle. Therefore, the design was limited to cooling with liquid nitrogen.

• Mechanical supports and alignment: The cryostat for the maser had to be thermally isolated, allowing liquid cryogen or closed cycle refrigerator operation, and provide adequate electrical and rf access to the resonator cavity. The challenge for thermal isolation is to simultaneously provide a short rigid mechanical support structure that also is thermally isolating. This was accomplished using zyarock spacers, countering the low yield strength under tension by compressionally preloading the zyarock. This arrangement, shown in Figure 4, was adequate to maintain the critical alignment of the storage bulb stem with the beam optics.

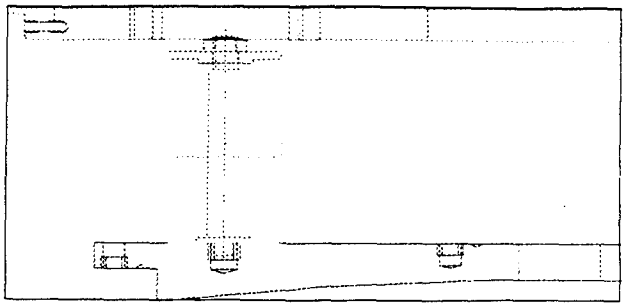

Figure 4. Detail of a zyaroc support.

• RF cabling: RF coaxial cables are typically good thermal conductors, and would result in unacceptably high LN_2 boil off and thermal gradients. The solution was to use cable with a stainless steel outer conductor, with the length chosen to balance the RF losses and the thermal conductivity.

• Temperature control at several temperatures: The YBCO-coated cavity had to be maintained at or below 77 K in order that it be superconducting. As discussed below, precise control of the temperature was required in order to stabilize the resonant frequency. This was made easier by the use of liquid nitrogen as the coolant, since it naturally remains at its boiling point. However, the boiling point varies with ambient pressure, as shown in Figure 5. With the10 kHz/K frequency dependence of the cavity, discussed below, changes of 10% in the pressure will produce a frequency shift of $\Delta\upsilon/\upsilon_0 = 1.8\cdot10^{-10}$. This shift would significantly perturb the operation of the maser, and thus a thermal control circuit was required. A circuit previously used to control a quartz clock was used for this purpose. A schematic is shown in Figure 6. The heater for the controller was wound around the cryostat.

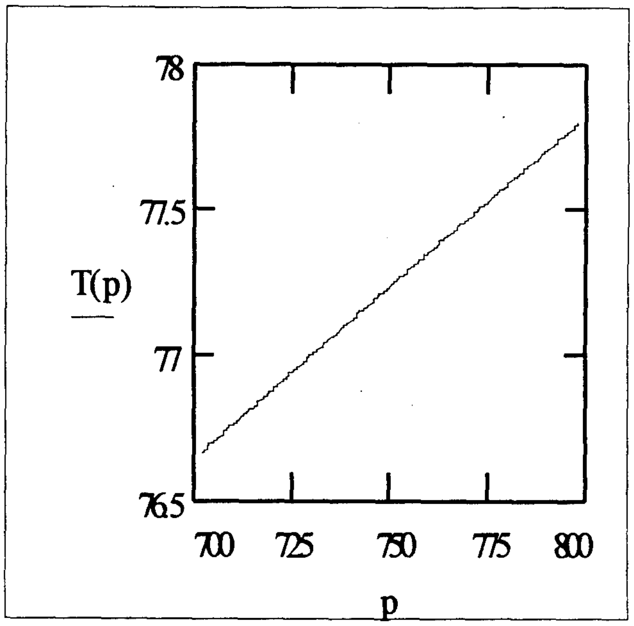

Figure 5. Temperature of the boiling point of liquid nitrogen as a function of the ambient pressure.

drive from Burleigh, and rough cavity tuning to within ±5kHz. Also, with this tuning system, maser performance could be measured over the complete temperature range. A varactor diode was used for fine tuning.

Magnetics

The maser is very sensitive to dc magnetic fields due to the Zeeman shift:

$$\frac{\Delta\nu}{\nu\Delta H}=3.87\times10^{-9}(Oe)^{-1}$$

over and great caremust be taken to isolate the interaction region from ambient fields. The original maser had cylindrical magnetic shields, which appeared adequate for the new design. The shields were placed around the entire new physics package, at room temperature. The shield performance was modeled using a finite element code (Maxwell™ 2-D magnetostatic package.) The results of the modeling are shown in Figures 10 -12. Figure 10 shows a plot of the magnetic flux lines, while

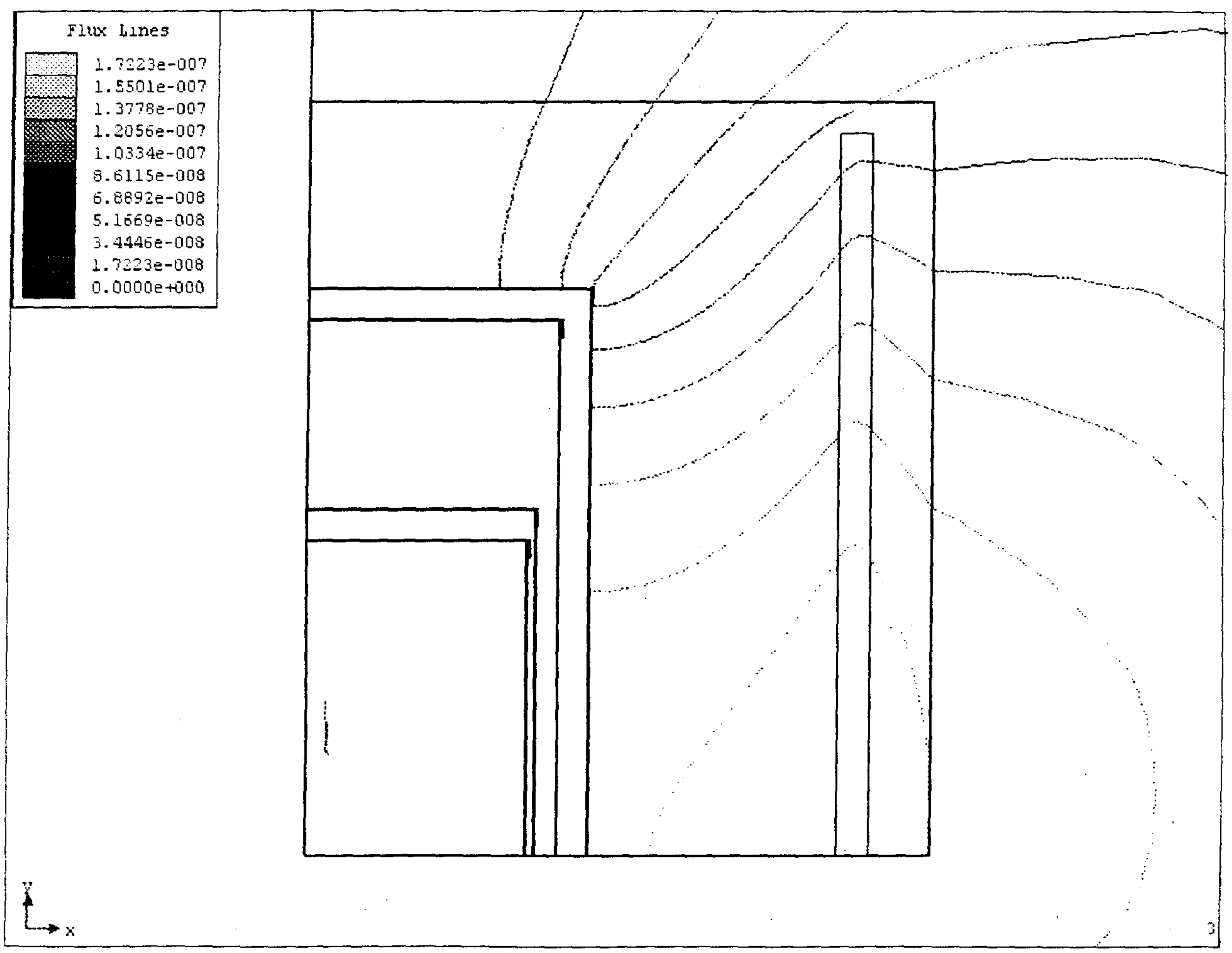

Figure 10. Plot of the magnetic field flux lines in the maser.

This results in a net reduction of the electrode gap, causing the frequency to decrease. Considering that all geometries are equal, resonators with copper, stainless steel, and superconducting electrodes will follow the same frequency vs. temperature curve. The range of the curve that is spanned will vary with the thermal expansion coefficients. For copper, the frequency dependence has been measured to be 10 kHz/K.

These thermal expansion effects require that the cavity is constructed with a mechanism for tuning the cavity as it is cooled from room temperature to 77° K. The easiest way to achieve the required range of tuning is to use a metallic or dielectric perturbation to the resonant fields. We considered each possibility and settled in dielectric tuning. This decision was made because of the optimal relative positions in the cavity of the dielectric or metallic perturbing volumes. The metallic perturbation is most effective when inserted into the magnetic fields of the resonator, which are along the longitudinal axis. This region of the cavity volume is occupied by the storage bulb. Conversely, a dielectric tuning paddle is most effective in the electric fields, which are concentrated in the electrode gape regions. Therefore, dielectric tuning could be performed without disturbing the storage bulb volume.

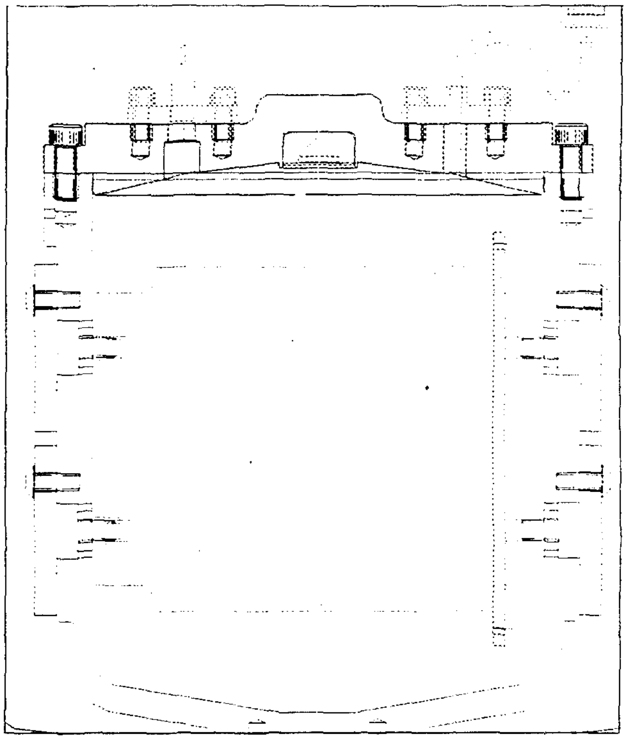

Figure 8. The quartz bulb with the tuning paddle. The cavity is of a diameter that fits between the bulb and the paddle, with the azimuthal alignment such that the paddle is roughly centered over the gap.

The Phase I results describe a sapphire paddle in the electric fields near the outer radius of the electrode gap. At that time we presumed that the paddle would pivot about in a longitudinal axis. We found that it would be very difficult to achieve this motion with feedthrough technology because of space limitations. The requirements for tuning the system were:

- move the sapphire within the cavity,

- locate or develop a means of mechanical feedthrough without increasing the cavity size,

- maintain the mechanical actuator at or near room temperature.

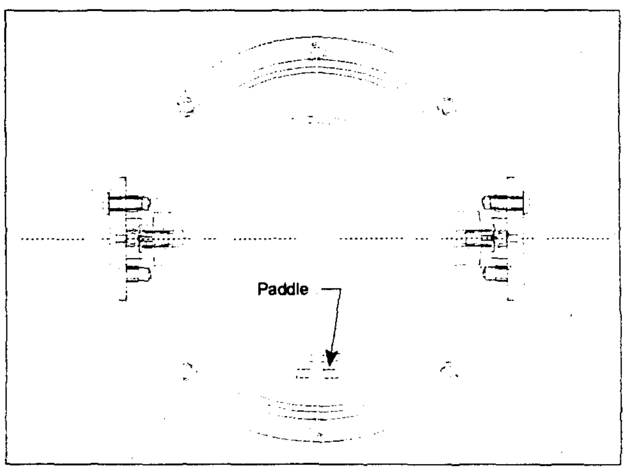

Figure 9. Cross section of the cavity and bulb.

The solution was to fix the dielectric to the quartz bulb, attach a mechanical actuator to the warm stem of the quartz bulb, rotate the bulb along the longitudinal axis so that the paddle can be gradually moved into and out of the electric field regions. This solution, shown in Figures 8 and 9, permitted us to achieve mechanical tuning without adding any new feedthroughs, use an off-the-shelf inchworm

Maser Fabrication

Cavity

The cavity, shown in Figures 14 and 15, was fabricated as planned. It was anticipated that the mechanical support structure would significantly decrease the resonant frequency from that determined by modeling. The resonant frequency was therefore measured before final machining of the electrode gap. The results of these measurements, which match well with the data obtained with a previous test version of the cavity (c.f. Interim Report), are shown in Figure 16.

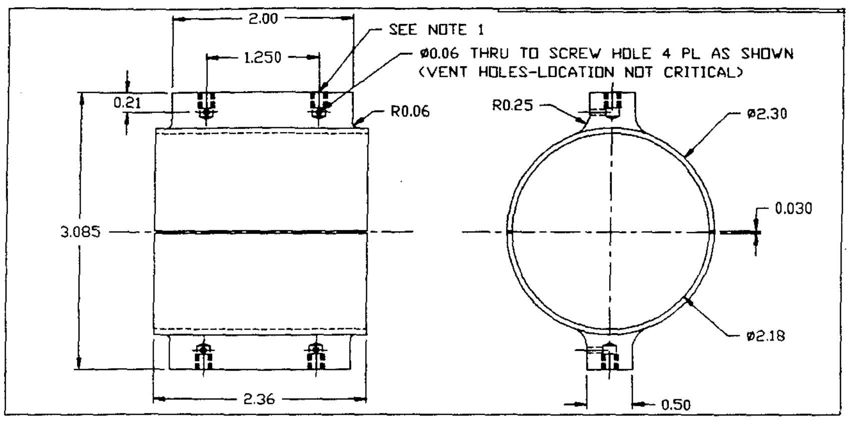

Figure 14. Drawing of the loop-gap resonator.

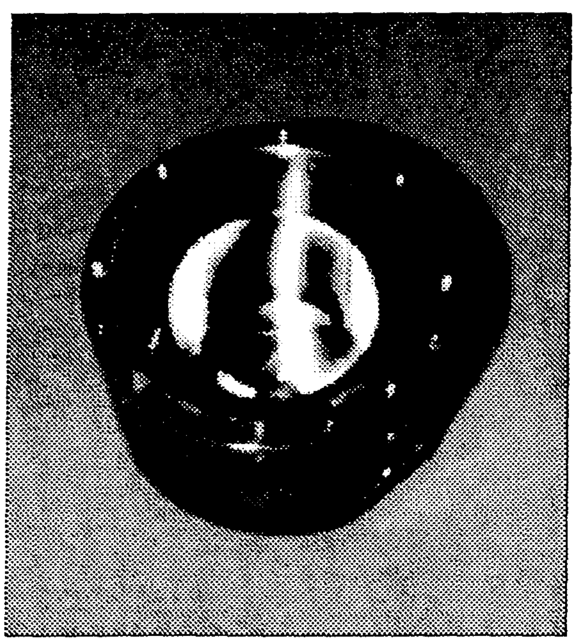

Figure 15. Photograph of the electrodes mounted inside th RF shield can of the loop gap resonator.

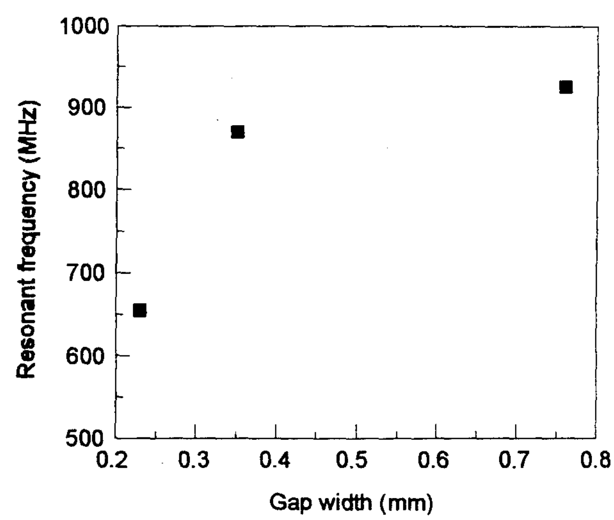

Figure 16. Results of the measurement of the resonant frequency of the loop-gap resonator as fabricated.

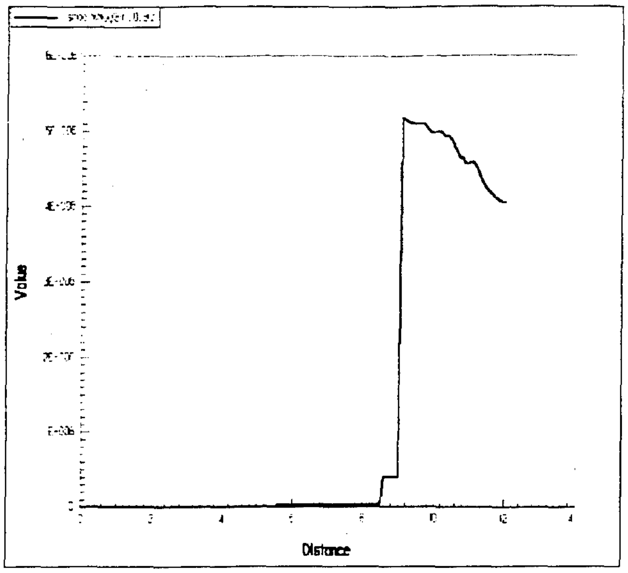

Figure 11. Magnetic field on the axis of the maser. The cavity extends from z=0 to z=8.

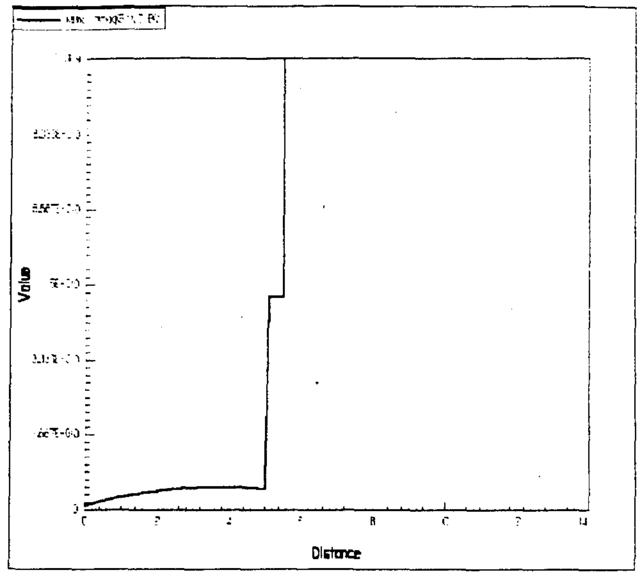

Figure 12. Magnified plot of the magnetic field along the z axis.

Figures 11 and 12 are plots of the magnetic field along the axis of the the shield. The center of the RF cavity is at z=0. The magnetic field is down by more than five orders of magnitude, typcial of the shield arrangement.

In the AF-1, the c-field was produced by a 21 turn coil epoxied to the inside of the magnetic shield. As determined in tests of the maser in its unmodified state, the magnetic field produced by that coil was not uniform enough for the device to mase. It was therefore replaced by a new coil, with a variable turn density. This turn density was optimized to yield a flat field profile shown in Figure 13. Additionally, the coil was counter-wound, rather than having the single, longitudinal return wire of the original coil. This eliminated the non-solenoidal contribution from the return wire.

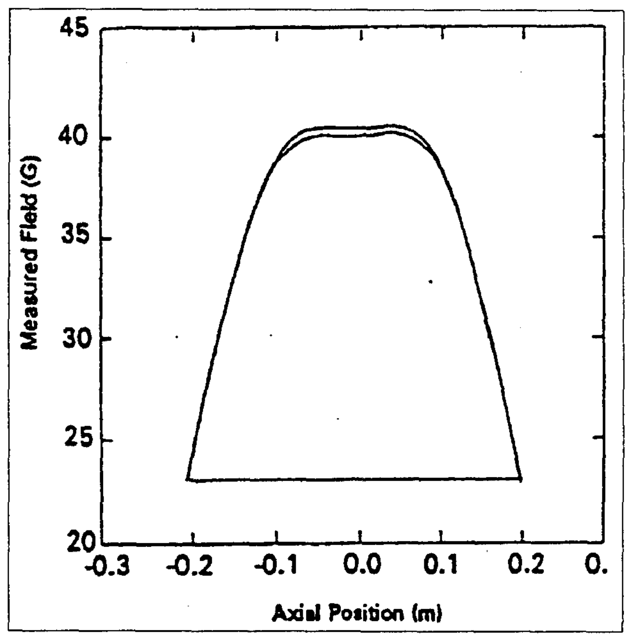

Figure 13. Profile of the C field produced by the new coil.

Parts Drawings

The drawings of the major parts are appended for future reference.

Measurements

Initial Tests (Tests of AF-1)

Our first step in the reconstruction of this maser was to benchmark the performance for the AF-1 maser before rebuilding it with the new elements. This would give us a relative measurement of the superconducting maser. The parameter chosen for comparison was the atomic line width, which parameter is relatively easy to measure. Other measures of performance take long to measure and are more dependent on systematic fluctuations. These fluctuations can often be corrected in engineering an optimized version of the maser.

During the benchmarking of AF-1, we replaced and repaired many of the original elements. The first element repaired was the original wiring. After years of disuse, the AF-1 had several blown transistors, and some bad wire contacts. The new c-field coil winding was used to give a more homogeneous magnetic field.

In operation, the refurbished maser performed very well. At c-field levels of about 100 mG, the measured maser line width was less that 1 Hz. This line width could only be achieved at high field levels because of residual magnetic field gradients at a low field that broadened the hydrogen resonance line. Since these tests, we have re-annealed all of the magnetic shielding elements in the maser. This should resolve any residual field issues and allow the measurement of the maser at much lower field levels of about 1 mG.

It should be noted that these measurements were made with the original cavity and bulb. This cavity was designed for active oscillation only. Therefore, it had only one microwave coupler. An interrogation signal was passed into the cavity and the return was measured using a directional coupler. The cavity designed for the Phase II program has two couplers for passive interrogation

The maser will be operated in passive mode when tested with the copper cavity at temperatures from 300 K to 77 K. These tests will allow to isolate the effects of operation at low temperatures from those associated specifically with the superconductor, such as the cavity Q and the magnetic shielding.

Initial Operation

For the passive measurements we will use the vector impedance technique of cavity interrogation. Using the combined phase and amplitude information of the signal this technique is expected to reduce the effect of cavity pulling significantly.[1] These measurements will include the characterization of frequency shifts and relaxation processes associated mainly with the teflon coating of the bulb. For determining the frequency stability of the oscillator signal, the maser will be operated in the active mode with the superconducting cavity cooled to 77 K. These measurements are performed by comparing the maser's frequency with that of an atomic clock of known stability by using the Allen deviation as the statistical measure. The increased temperature sensitivity of the wall shift as well as the cavity pulling is expected to limit the stability of the operation of the compact maser at 77 K.

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[1] Details of this technique are discussed in W.M. Golding, et al., ``Reduction of Cavity Pulling in a Passive Hydrogen Maser", Proc. of the 20th PTTI (1988).

Tuning of the cavity was accomplished in several steps. The adjustment of the gap was the first, and would be done only prior to the final assembly. Once the cavity was in place, adjustment to the resonant frequency would be made by the sapphire paddle, positioned near one of the gaps. The paddle was connected to the glass bulb which could be rotated around its axis, as discussed below. The total frequency sweep would be greater than 15 MHz, as shown in Figure 17. The resolution of the positioner is about 1 micron, giving a frequency resolution of 1 kHz. The final, and most precise tuning, was provided by a varacter diode coupled to the cavity via a loop antenna on the top of the cavity. The maximum frequency shift produced in this manner is expected to be about 30 kHz.

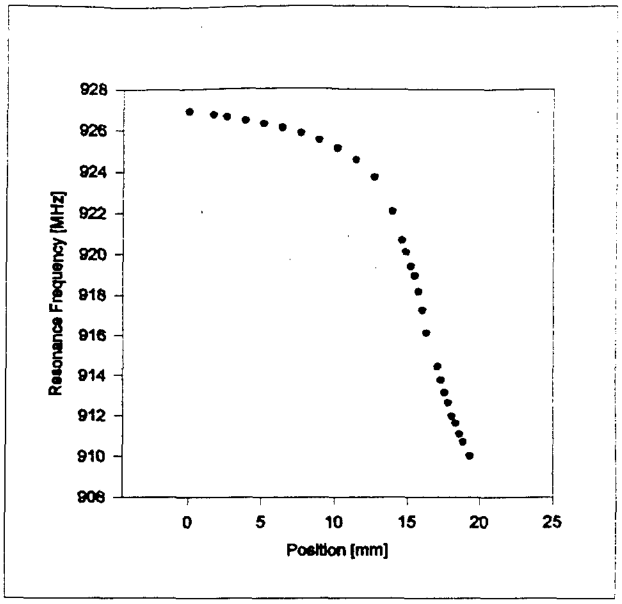

Figure 17. Shift in resonant frequency produced by rotating the paddle over 33 degrees (18.4 mm) across the cavity gap.

Glass Bulb

The bulb, shown in Figures 19 and 18, was fabricated from quartz glass. The sapphire tuning paddle was connected to the bulb via two small posts so that rotation of the bulb produced a movement of the paddle across the cavity gap. The rotation of the bulb was done by a piezo-electric "inchworm" drive. The thermal expansion coefficients of the glass and sapphire are significantly different, and there was concern that the supports for the paddle would be broken during cool down. To avoid this, one of the two support holes in the paddle was opened up to form a slot. This arrangement proved to be very fragile, and in fact, failed. Finally, the paddle was attached at one end with low temperature epoxy.

As is usual for a hydrogen maser, the inside of the bulb was coated with Teflon™ to minimize the interaction of the wall with the hydrogen atoms. The coating was applied by Sigma Tau, Inc., a long-standing manufacturer of conventional hydrogen masers, using a complex proprietary process.

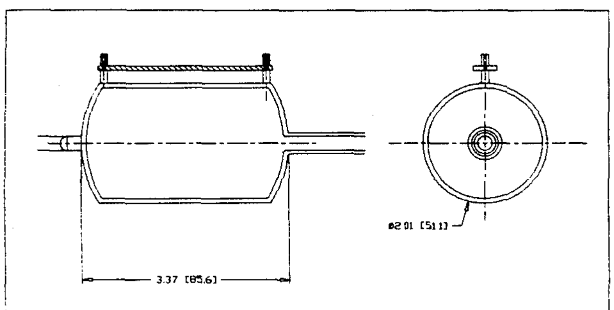

Figure 19. Drawing of the glass bulb for the hydrogen maser. The tuning paddle is shown on the right.

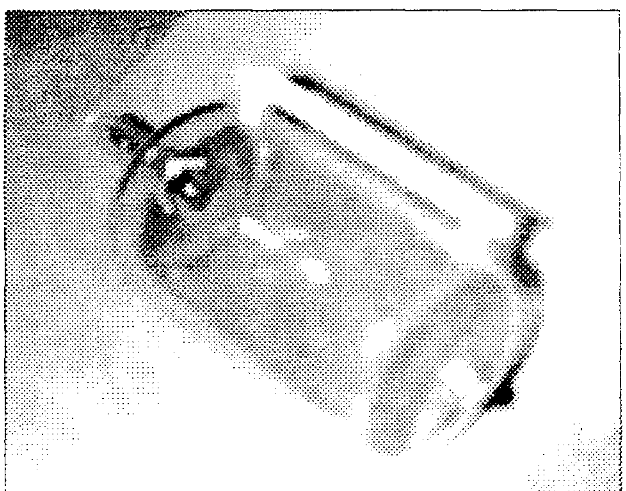

Figure 18. Photograph of the glass bulb, with tuning paddle, for the hydrogen maser.

Conclusions

Although the maser was not fully operational, several important conclusions were drawn. The first is that the maser would be more difficult to operate than anticipated. The primary cause for this was in its sensitivity to thermal fluctuations. This was due to operating at cryogenic temperatures, and was more than an order of magnitude higher than is found in a conventional (room temperature) hydrogen maser. The second was that the added complexity and volume of the elements needed for cryogenic operation significantly reduced the attractiveness of the maser as a commercial product. Given these two drawbacks, and the limited market for hydrogen masers in general, it was determined that no further effort should be made toward commercialization. However, the program was not without significant benefit. It established a technology base that has allowed PSI to embark on the development of a novel rubidium maser. This device is expected to have a relatively large commercial and military market, a perception backed by our industrial partner who is putting almost $200,000 into the development in our Phase II.

Personnel Supported

The scientists who contributed to this research include David B. Opie, Michael E. Read, and Geoffrey Bird of Physical Sciences, Inc. and S.K. Remillard, H. E. Schone of the College of William and Mary.

Publications

"Magnetic Shielding By $Y_1Ba_2Cu_3O_{7-\delta}$ Thick Films" published in IEEE Transactions on Applied Superconductivity, Vol.3, No. 1, March 1993. This article article contributors include: D.B. Opie, M.E. Read, S.K. Remillard, M. J. Brown, W. J. Kossler, H. E. Schone, T. W. Button and N. McAlford

Appendix I

Magnetic Shielding by YBCO Thick Films

Consideration was given of using superconducting magnetic shields. These shields were expected to be much more effective than conventional mu-metal ones. However, after an initial investigation, it was decided that use of superconducting shields would entail an effort beyond the scope of the program, and that conventional shields would be used. A paper documenting these shields is appended.

Appendix II

Parts Drawings

REVISIONS

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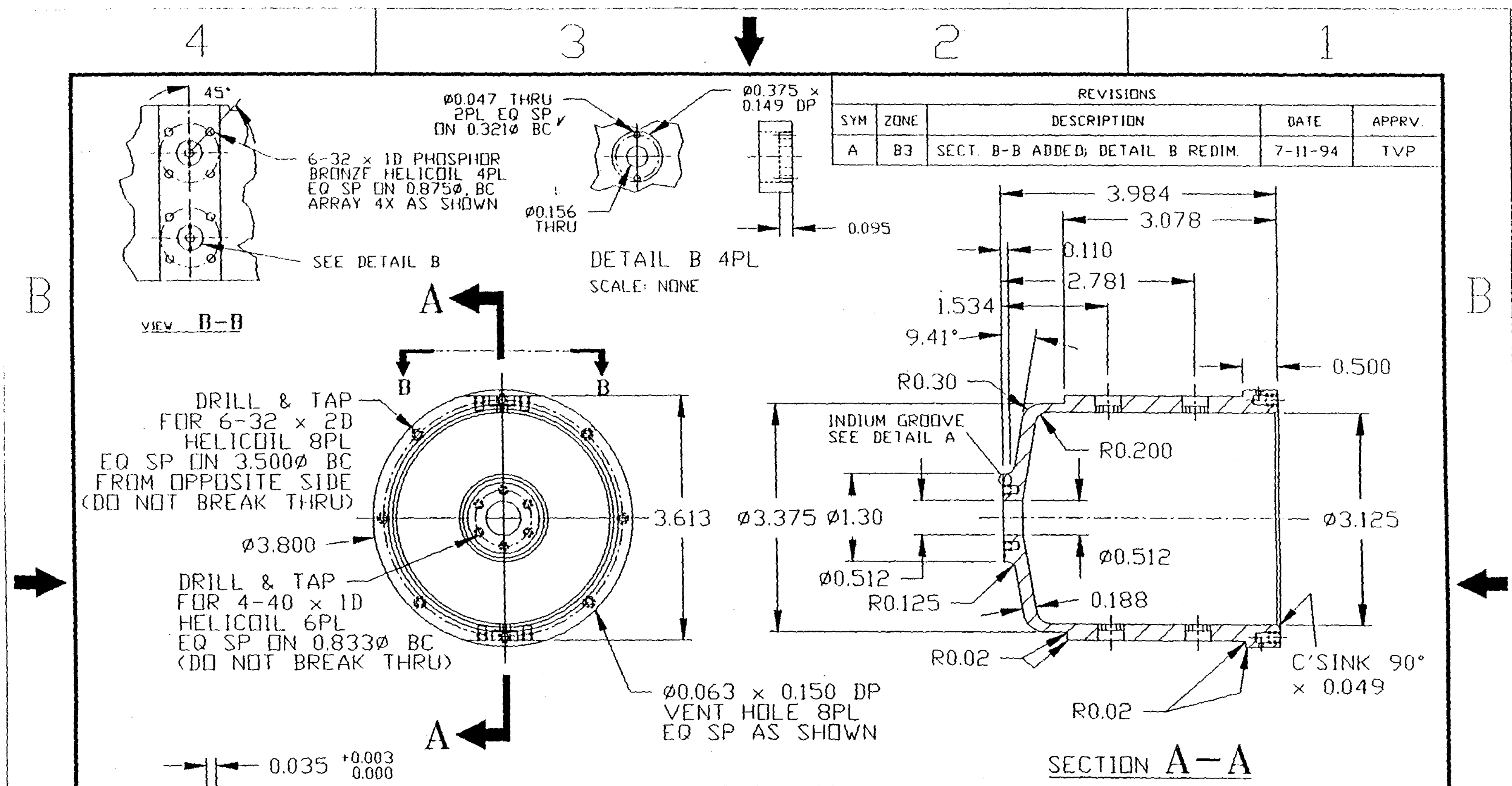

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ENGLISH [X] INCHES	METRIC [ ] MILLIMETERS
FRAC.±1/64	
DECIMALS: .XX ±.01 .XXX ±.005 .XXXX ± .0005	DECIMALS: .X ±.1 .XX±.01
ANGLES ± 1°-0'	

MATERIAL
OFHC COPPER

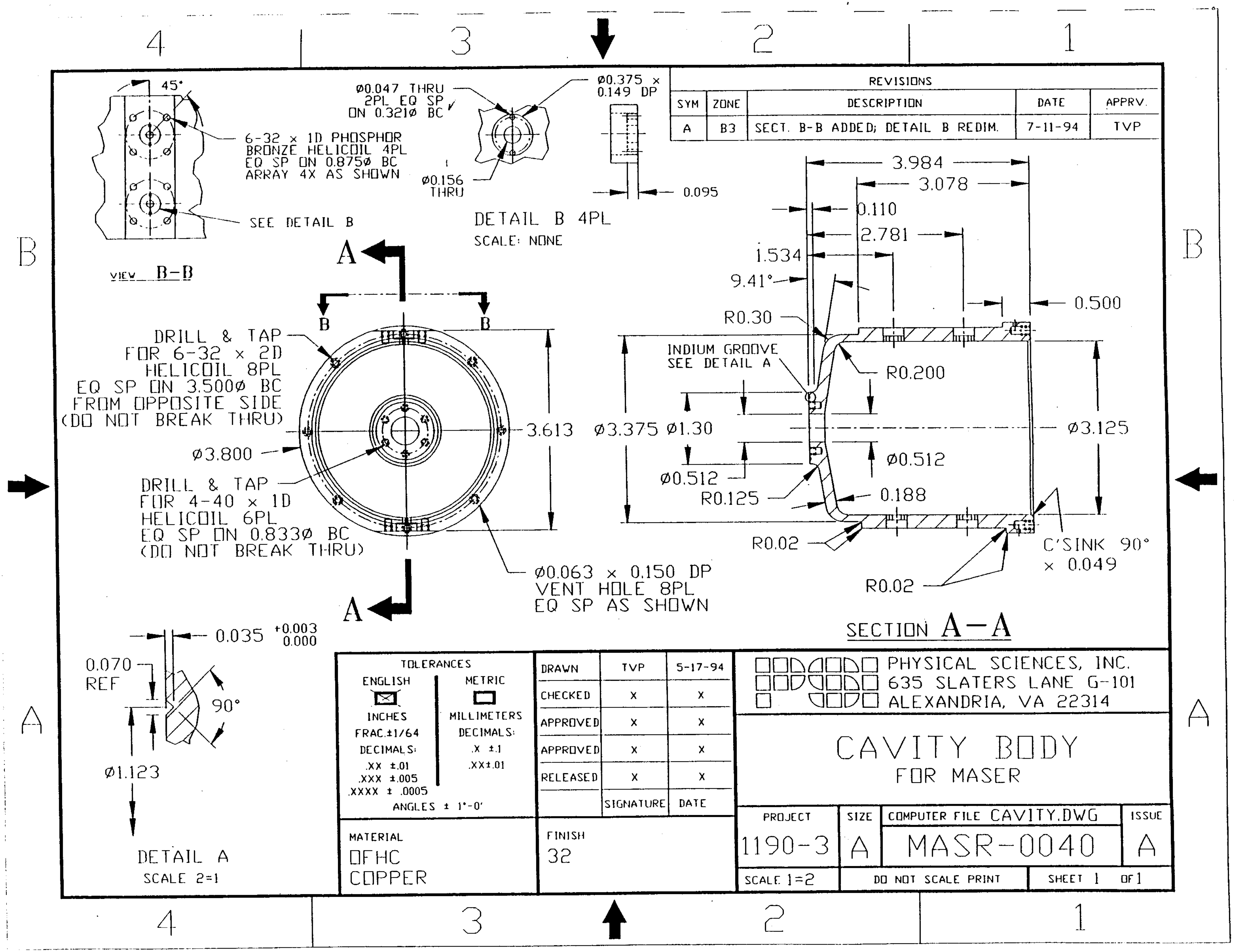
DRAWN	TVP	5-17-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X
	SIGNATURE	DATE

FINISH
32

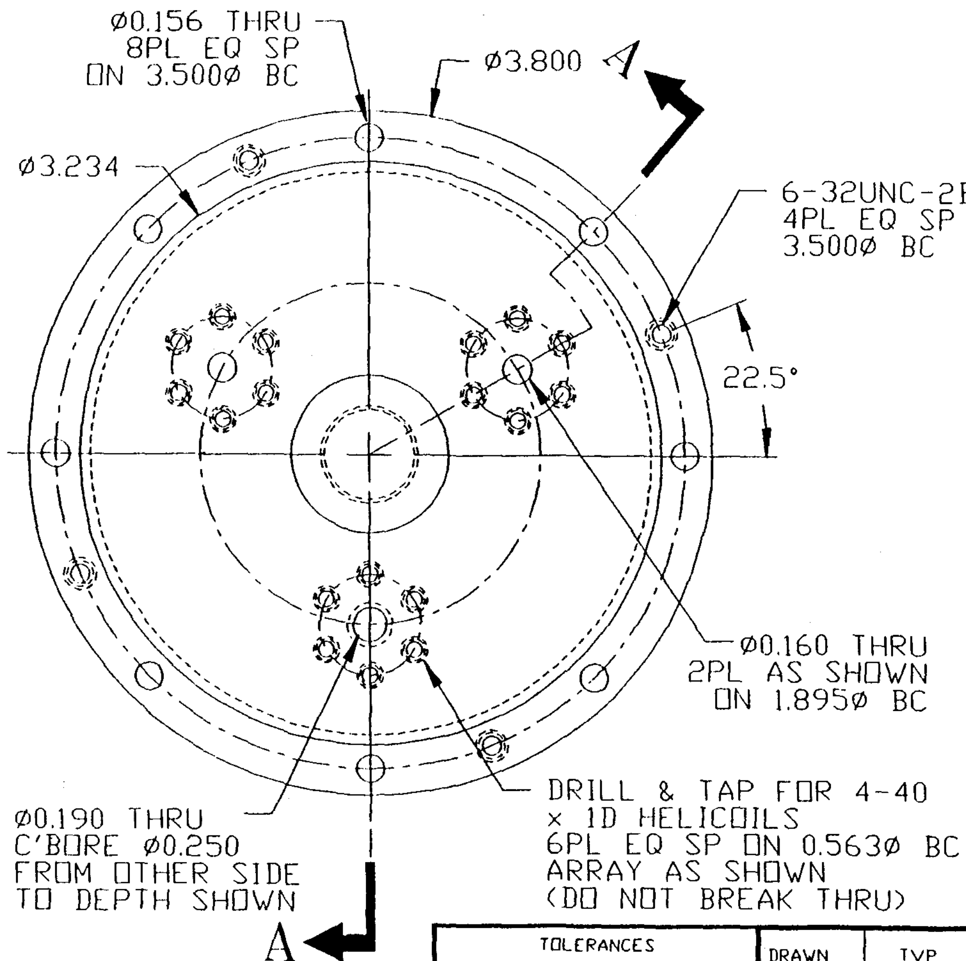
PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

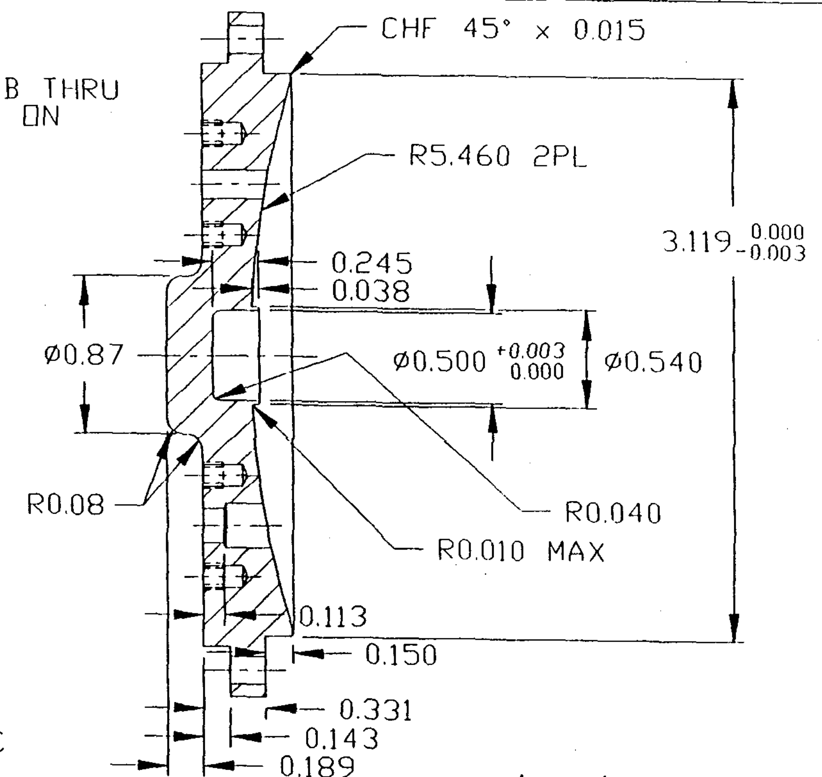
CAVITY BODY
FOR MASER

PROJECT	SIZE	COMPUTER FILE CAVITY.DWG	ISSUE
1190-3	A	MASR-0040	A
SCALE 1=2		DO NOT SCALE PRINT	SHEET 1 OF 1


REVISIONS
SYM | ZONE | DESCRIPTION | DATE | APPRV.
A | B3 | SECT. B-B ADDED; DETAIL B REDIM. | 7-11-94 | TVP
45°
6-32 x 1D PHOSPHOR BRONZE HELICOIL 4PL EQ SP ON 0.875Ø BC ARRAY 4X AS SHOWN
SEE DETAIL B
VIEW B-B
Ø0.047 THRU 2PL EQ SP ON 0.321Ø BC
Ø0.375 x 0.149 DP
Ø0.156 THRU
0.095
DETAIL B 4PL
SCALE: NONE
A
B
B
DRILL & TAP FOR 6-32 x 2D HELICOIL 8PL EQ SP ON 3.500Ø BC FROM OPPOSITE SIDE (DO NOT BREAK THRU)
3.613
Ø3.800
DRILL & TAP FOR 4-40 x 1D HELICOIL 6PL EQ SP ON 0.833Ø BC (DO NOT BREAK THRU)
Ø0.063 x 0.150 DP VENT HOLE 8PL EQ SP AS SHOWN
A
3.984
3.078
0.110
2.781
1.534
9.41°
0.500
R0.30
INDIUM GROOVE SEE DETAIL A
R0.200
Ø3.375 Ø1.30
Ø3.125
Ø0.512
Ø0.512
R0.125
0.188
R0.02
C'SINK 90° x 0.049
R0.02
SECTION A-A
0.035 +0.003 0.000
0.070 REF
90°
Ø1.123
DETAIL A
SCALE 2=1
TOLERANCES
ENGLISH
INCHES
FRAC.±1/64
DECIMALS:
.XX ±.01
.XXX ±.005
.XXXX ± .0005
METRIC
MILLIMETERS
DECIMALS:
.X ±.1
.XX±.01
ANGLES ± 1°-0'
DRAWN | TVP | 5-17-94
CHECKED | X | X
APPROVED | X | X
APPROVED | X | X
RELEASED | X | X
SIGNATURE | DATE
MATERIAL
OFHC COPPER
FINISH
32
PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314
CAVITY BODY
FOR MASER
PROJECT 1190-3
SIZE A
COMPUTER FILE CAVITY.DWG
MASR-0040
ISSUE A
SCALE 1=2
DO NOT SCALE PRINT
SHEET 1 OF 1

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.
A	B2,4	Ø0.160 THRU MODIFIED FOR DIODE	7-19-94	GB





SECTION A—A

TOLERANCES		DRAWN	TVP	3-24-94
ENGLISH ☒ INCHES	METRIC ☐ MILLIMETERS	CHECKED	x	x
FRAC.±1/64	DECIMALS:	APPROVED	x	x
DECIMALS: .XX ±.01 .XXX ±.005 .XXXX ± .0005	.X ±.1 .XX±.01	APPROVED	x	x
ANGLES ± 1°-0'		RELEASED	x	x
			SIGNATURE	DATE

MATERIAL
OFHC
COPPER

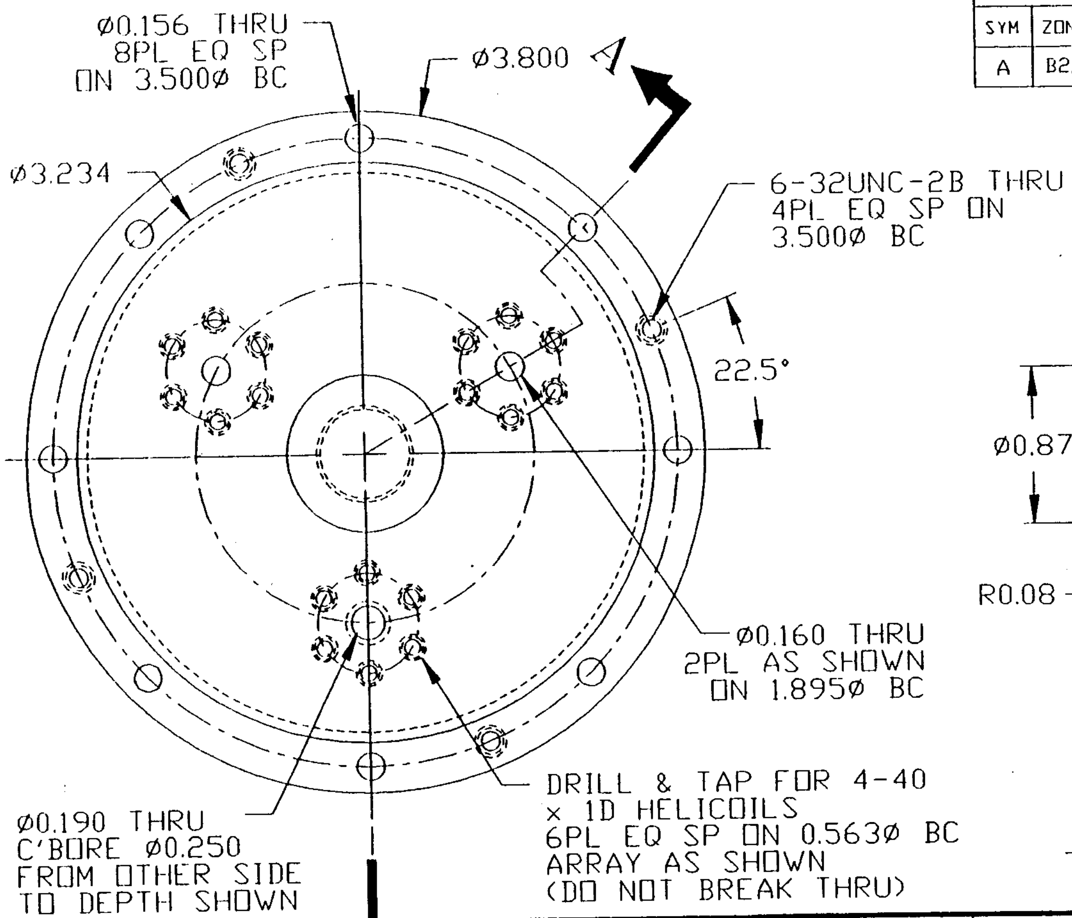
FINISH
32

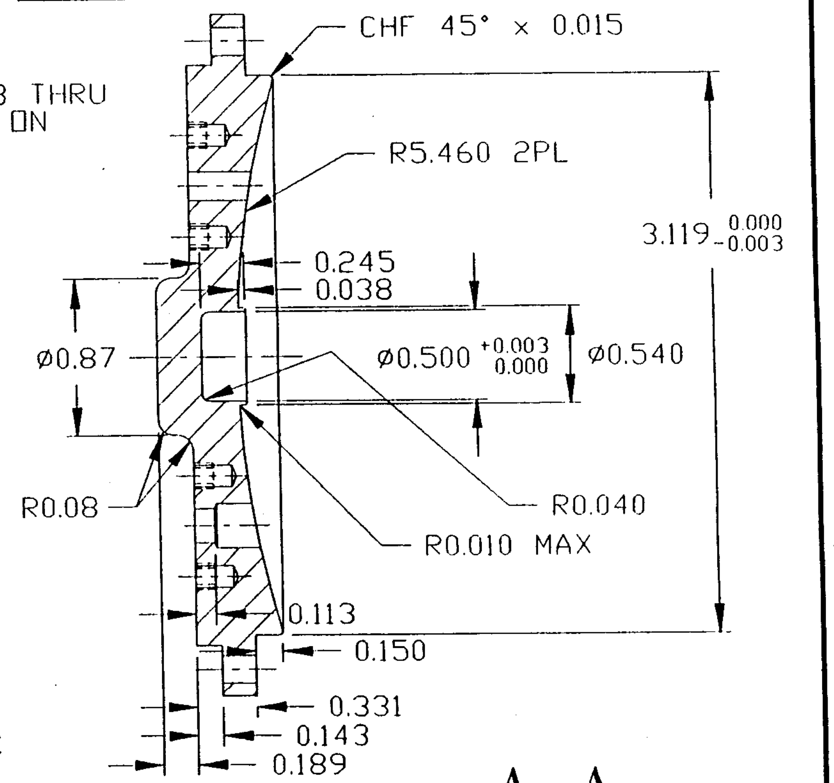
PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

CAVITY COVER
FOR MASER

PROJECT	SIZE	COMPUTER FILE CAVTCVR.DWG	ISSUE
1190-3	A	MASR-0041	A
SCALE 1=1	DO NOT SCALE PRINT		SHEET 1 OF 2

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.
A	B2,4	ø0.160 THRU MODIFIED FOR DIODE	7-19-94	GB





SECTION A−A

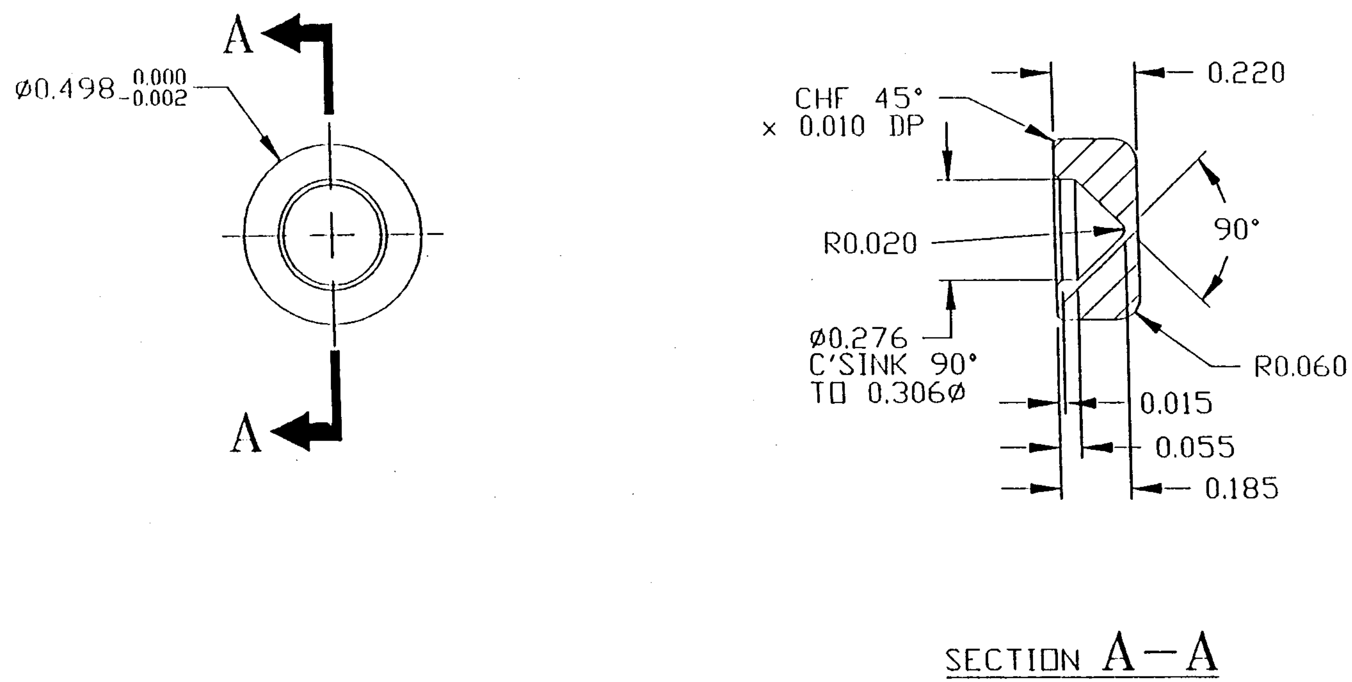
TOLERANCES					
ENGLISH ☒ INCHES FRAC.±1/64 DECIMALS: .XX ±.01 .XXX ±.005 .XXXX ± .0005	METRIC ☐ MILLIMETERS DECIMALS: .X ±.1 .XX±.01	DRAWN	TVP	3-24-94	
ANGLES ± 1°-0'		CHECKED	X	X	
		APPROVED	X	X	
		APPROVED	X	X	
		RELEASED	X	X	
			SIGNATURE	DATE	
MATERIAL OFHC COPPER		FINISH 32			

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

CAVITY COVER
FOR MASER

PROJECT	SIZE	COMPUTER FILE CAVTCVR.DWG	ISSUE
1190-3	A	MASR-0041	A
SCALE 1=1		DO NOT SCALE PRINT	SHEET 1 OF 2

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



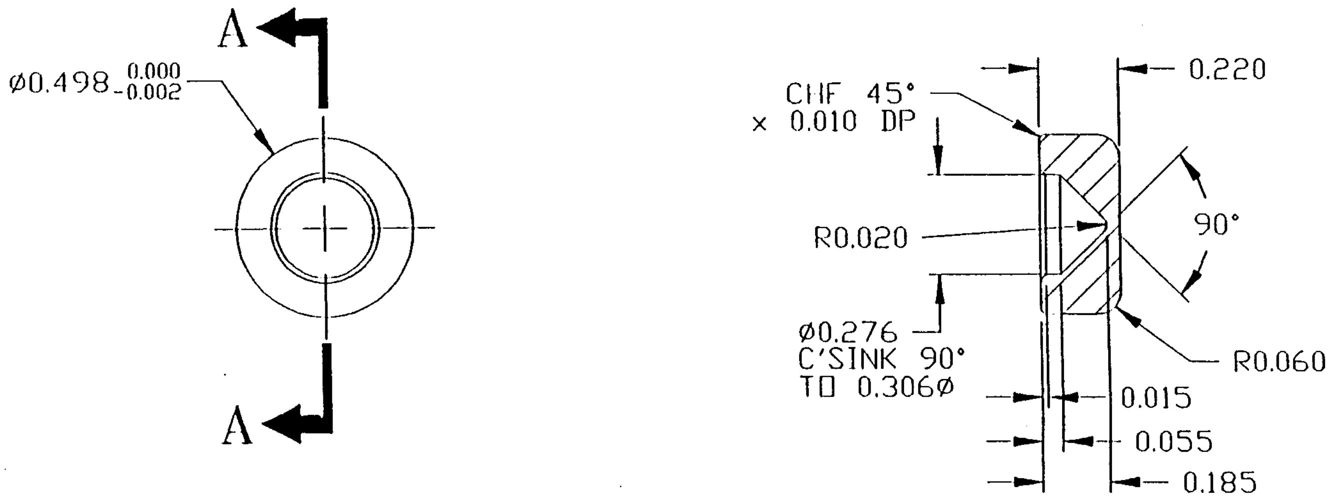
TOLERANCES		DRAWN	TVP	6-21-94
ENGLISH ☒ INCHES FRAC.±1/64 DECIMALS: .XX ±.01 .XXX ±.005 .XXXX ± .0005	METRIC ☐ MILLIMETERS DECIMALS: .X ±.1 .XX±.01	CHECKED	X	X
		APPROVED	X	X
		APPROVED	X	X
		RELEASED	X	X
ANGLES ± 1°-0'			SIGNATURE	DATE
MATERIAL TEFLON		FINISH 32		

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

BULB BEARING
FOR MASER

PROJECT	SIZE	COMPUTER FILE BLBBRNG.DWG	ISSUE
1190-3	A	MASR-0049	
SCALE 2=1	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



SECTION A–A

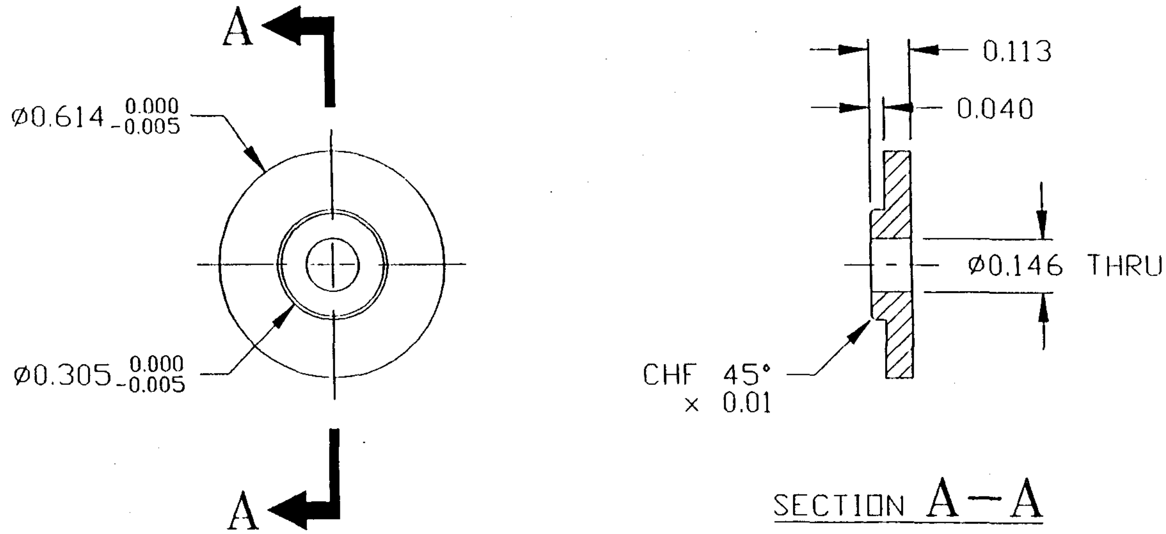
TOLERANCES		DRAWN	TVP	6-21-94
ENGLISH ☒ INCHES	METRIC ☐ MILLIMETERS	CHECKED	X	X
FRAC.±1/64	DECIMALS:	APPROVED	X	X
DECIMALS:	.X ±.1	APPROVED	X	X
.XX ±.01 .XXX ±.005 .XXXX ± .0005	.XX±.01	RELEASED	X	X
ANGLES ± 1°-0'			SIGNATURE	DATE
MATERIAL TEFLON		FINISH 32		

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

BULB BEARING
FOR MASER

PROJECT	SIZE	COMPUTER FILE BLBBRNG.DWG	ISSUE
1190-3	A	MASR-0049	
SCALE 2=1	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



SECTION A–A

3 REQ'D

TOLERANCES		DRAWN	TVP	4-22-94
ENGLISH ☒ INCHES	METRIC ☐ MILLIMETERS	CHECKED	X	X
FRAC.±1/64 DECIMALS: .XX ±.01 .XXX ±.005 .XXXX ± .0005	DECIMALS: .X ±.1 .XX±.01	APPROVED	X	X
		APPROVED	X	X
ANGLES ± 1°-0'		RELEASED	X	X
			SIGNATURE	DATE

MATERIAL
STAINLESS STEEL 304 ALLOY

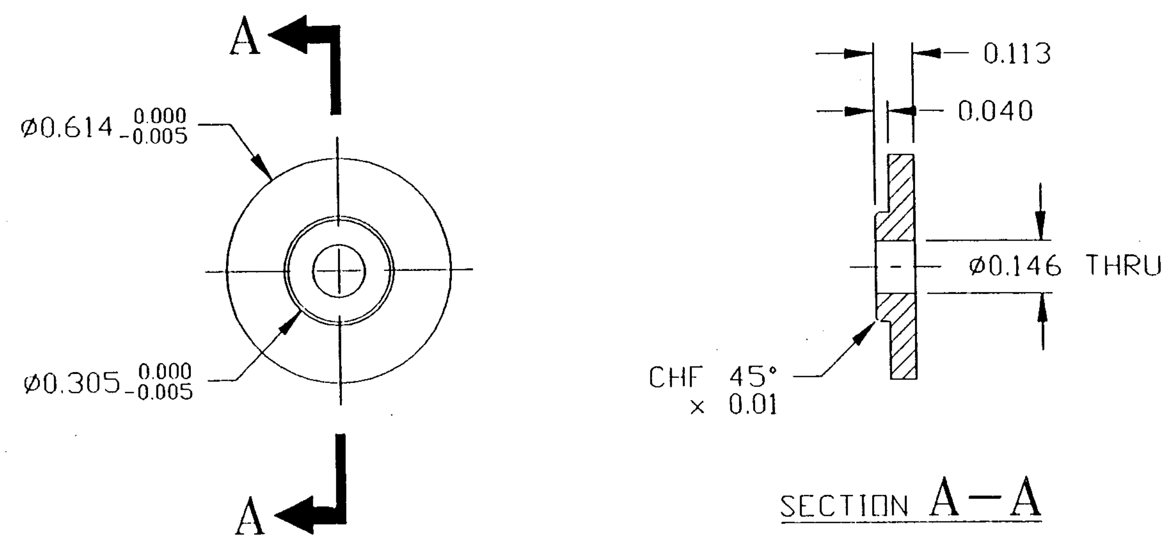
FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

COLUMN CAP
FOR MASER

PROJECT	SIZE	COMPUTER FILE COLMCAP.DWG	ISSUE
1190-3	A	MASR-0050	
SCALE 2=1	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



3 REQ'D

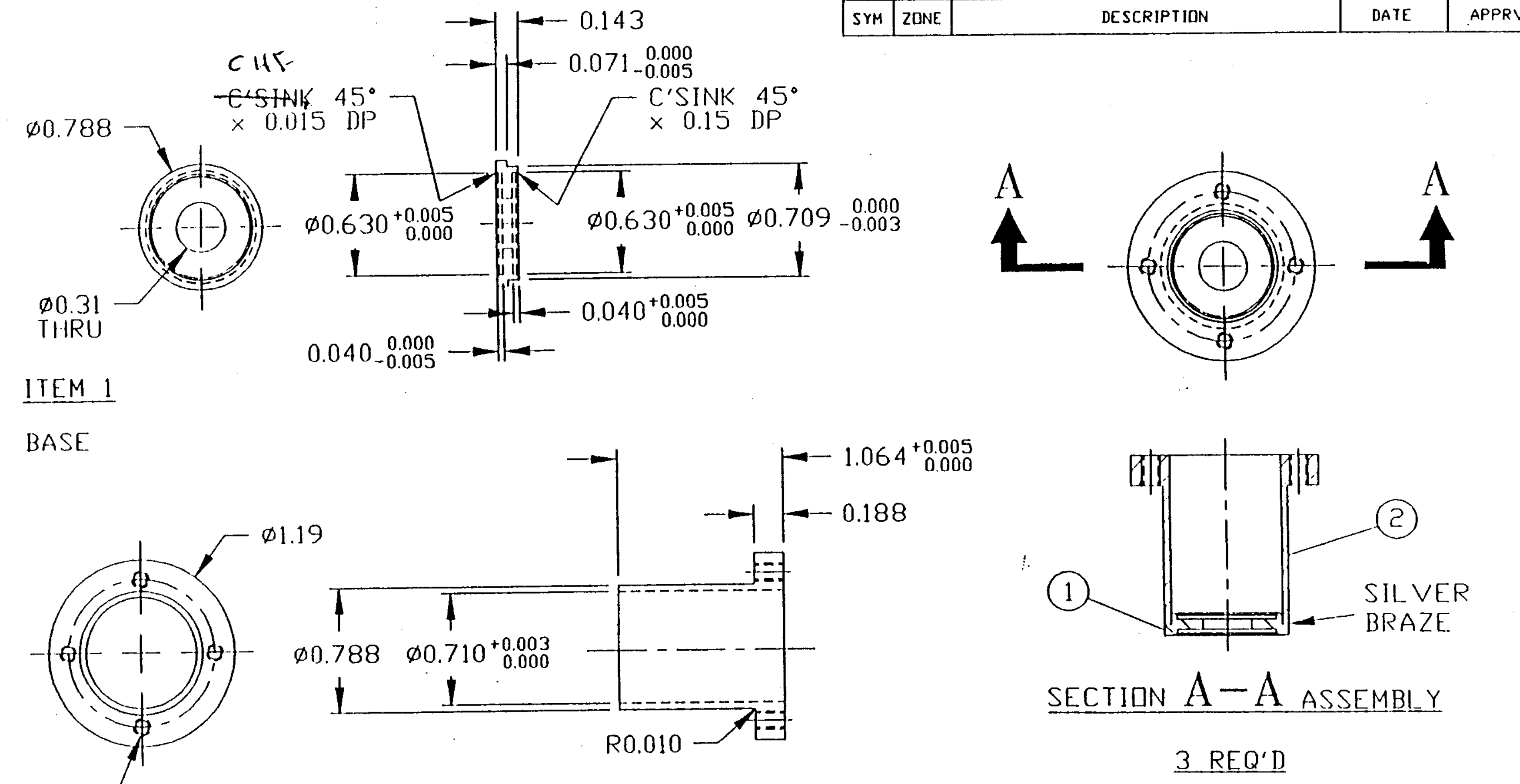
TOLERANCES				
ENGLISH ☒ INCHES FRAC.±1/64 DECIMALS: .XX ±.01 .XXX ±.005 .XXXX ± .0005	METRIC ☐ MILLIMETERS DECIMALS: .X ±.1 .XX±.01	DRAWN	TVP	4-22-94
ANGLES ± 1°-0'		CHECKED	X	X
		APPROVED	X	X
		APPROVED	X	X
		RELEASED	X	X
			SIGNATURE	DATE
MATERIAL STAINLESS STEEL 304 ALLOY		FINISH 32		

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

COLUMN CAP
FOR MASER

PROJECT	SIZE	COMPUTER FILE COLMCAP.DWG	ISSUE
1190-3	A	MASR-0050	
SCALE 2=1	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



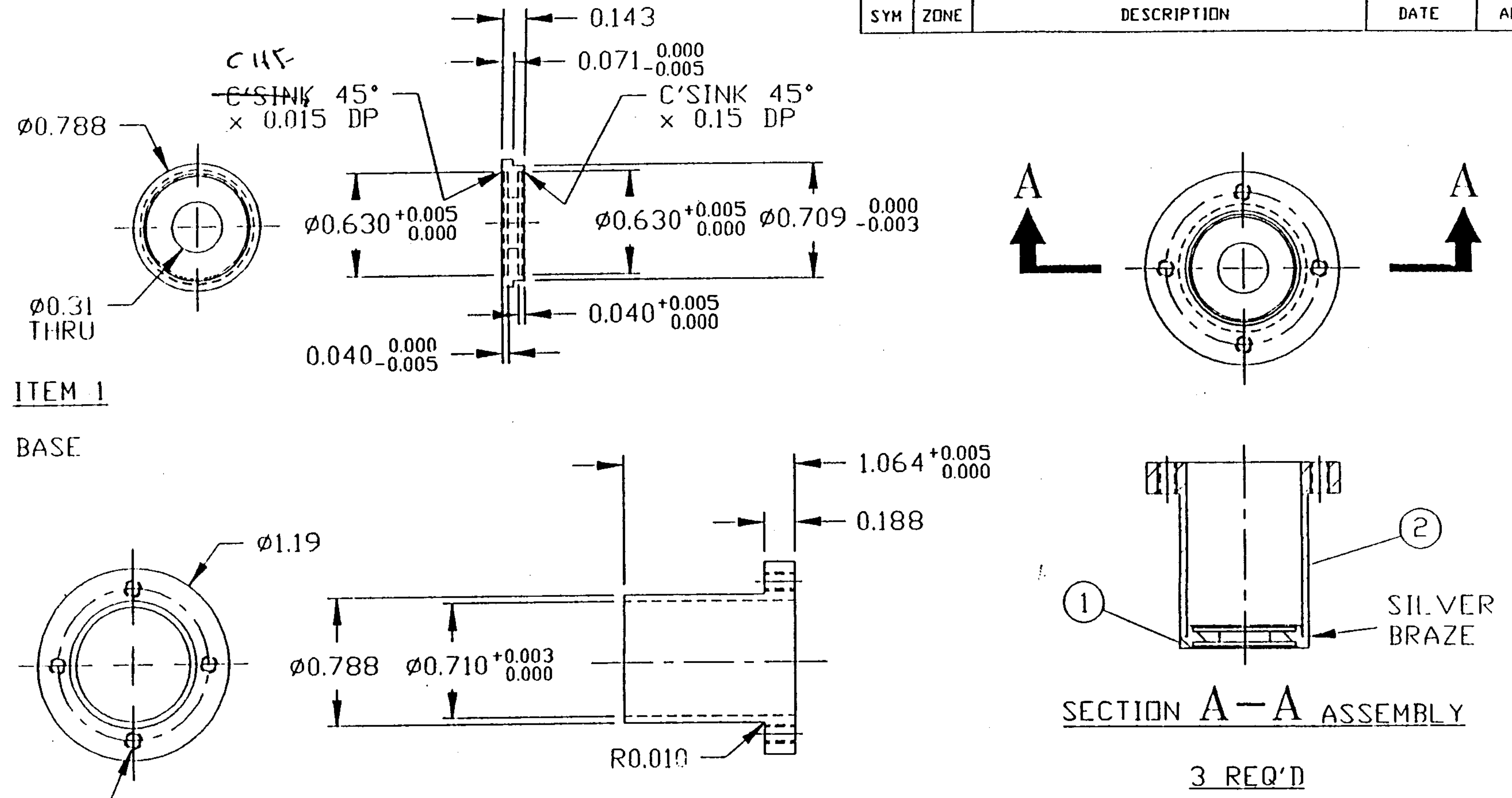
TOLERANCES					
ENGLISH ☒ INCHES FRAC.±1/64 DECIMALS: .XX ±.01 .XXX ±.005 .XXXX ± .0005	METRIC ☐ MILLIMETERS DECIMALS: .X ±.1 .XX±.01	DRAWN	TVP	4-25-94	
ANGLES ± 1°-0'		CHECKED	X	X	
		APPROVED	X	X	
		APPROVED	X	X	
		RELEASED	X	X	
			SIGNATURE	DATE	
MATERIAL STAINLESS STEEL 304 ALLOY		FINISH 32			

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

COLUMN FLANGE ASSEMBLY FOR MASER

PROJECT	SIZE	COMPUTER FILE COLMFLNG.DWG	ISSUE
1190-3	A	MASR-0051	
SCALE 1=1	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



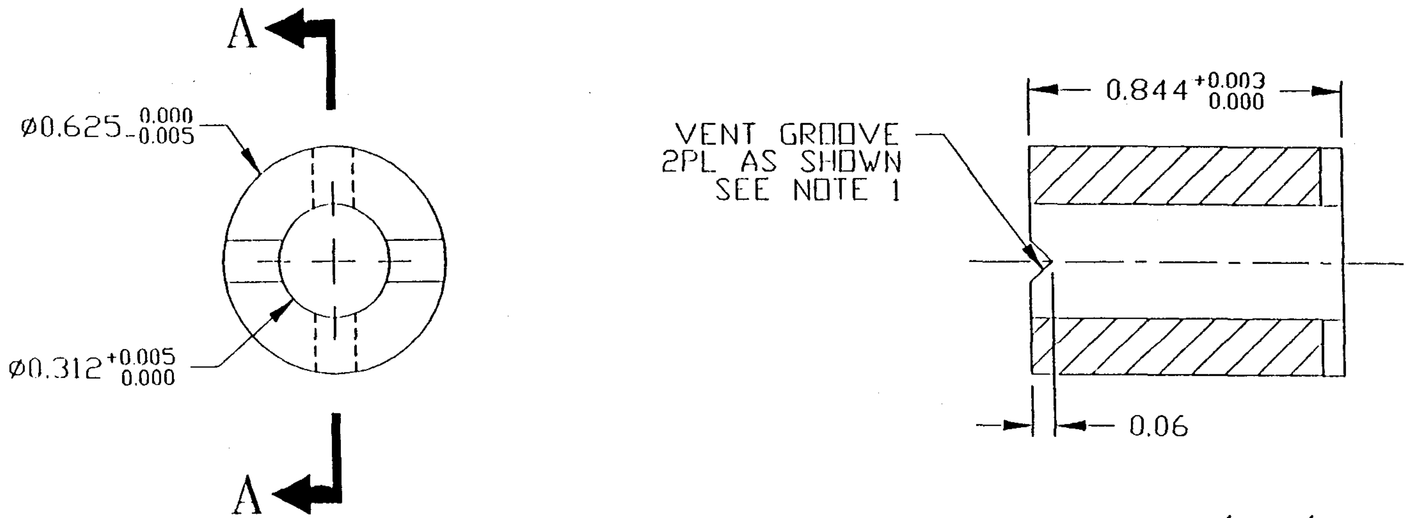
TOLERANCES			DRAWN	TVP	4-25-94
ENGLISH ☒ INCHES FRAC.±1/64 DECIMALS: .XX ±.01 .XXX ±.005 .XXXX ± .0005	METRIC ☐ MILLIMETERS DECIMALS: .X ±.1 .XX±.01		CHECKED	X	X
			APPROVED	X	X
			APPROVED	X	X
			RELEASED	X	X
ANGLES ± 1°-0'				SIGNATURE	DATE
MATERIAL STAINLESS STEEL 304 ALLOY			FINISH 32		

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

COLUMN FLANGE ASSEMBLY FOR MASER

PROJECT	SIZE	COMPUTER FILE COLMFLNG.DWG	ISSUE
1190-3	A	MASR-0051	
SCALE 1=1	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



SECTION A—A

6 REQ'D

NOTES:

1. GROOVE DIMS. NOT CRITICAL

TOLERANCES	
ENGLISH ☒ INCHES	METRIC ☐ MILLIMETERS
FRAC.±1/64	DECIMALS:
DECIMALS:	.X ±.1
.XX ±.01	.XX±.01
.XXX ±.005	
.XXXX ± .0005	
ANGLES ± 1°-0'	

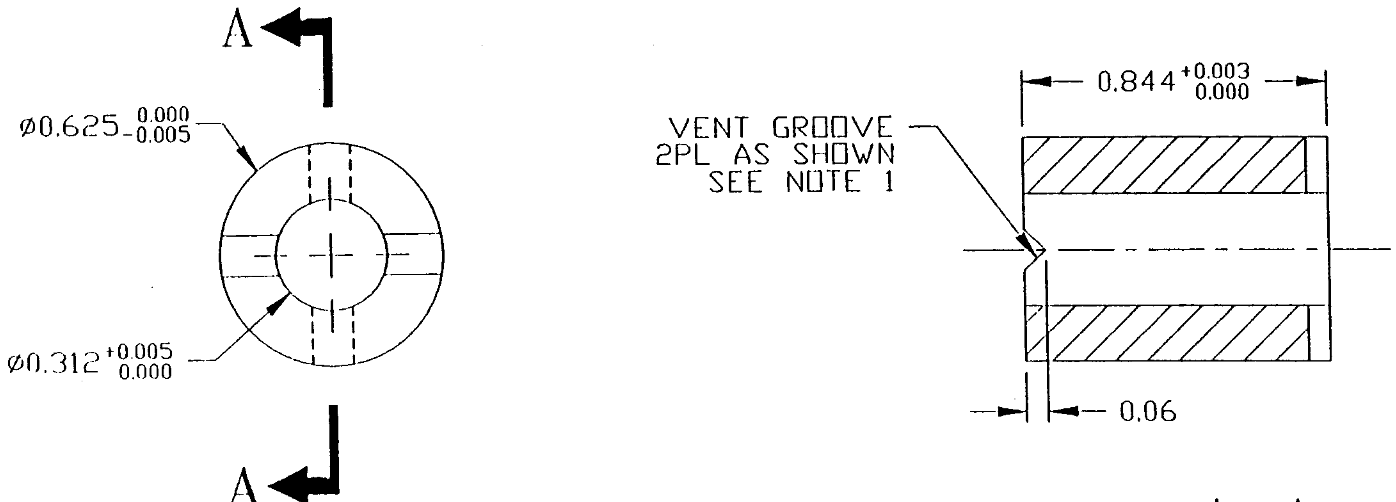
	SIGNATURE	DATE
DRAWN	TVP	4-25-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X

MATERIAL	FINISH
ZYAROCK	32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

COLUMN INSULATOR FOR MASER

PROJECT	SIZE	COMPUTER FILE COLMINS.DWG	ISSUE
1190-3	A	MASR-0052	
SCALE 2=1		DO NOT SCALE PRINT	SHEET 1 OF 1



SECTION A–A

6 REQ'D

NOTES:

1. GROOVE DIMS. NOT CRITICAL

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.

TOLERANCES

ENGLISH ☒ INCHES	METRIC ☐ MILLIMETERS
FRAC.±1/64	
DECIMALS:	DECIMALS:
.XX ±.01	.X ±.1
.XXX ±.005	.XX±.01
.XXXX ± .0005	

ANGLES ± 1°-0'

	SIGNATURE	DATE
DRAWN	TVP	4-25-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X

MATERIAL
ZYAROCK

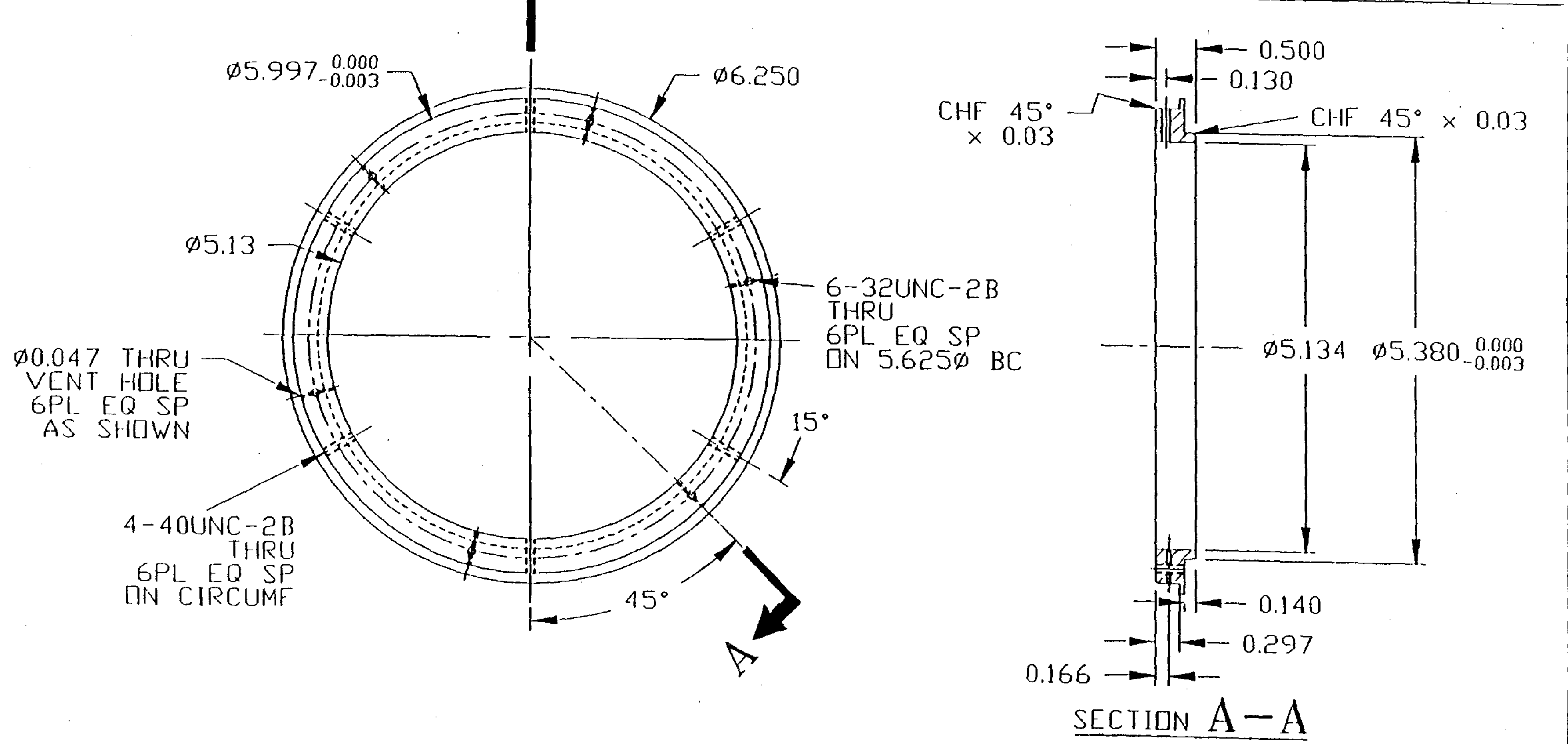
FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

COLUMN INSULATOR
FOR MASER

PROJECT	SIZE	COMPUTER FILE COLMINS.DWG	ISSUE
1190-3	A	MASR-0052	
SCALE 2=1	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



TOLERANCES		DRAWN	TVP	3-28-94
ENGLISH ☒ INCHES	METRIC ☐ MILLIMETERS	CHECKED	X	X
FRAC.±1/64	DECIMALS:	APPROVED	X	X
DECIMALS: .XX ±.01	.X ±.1	APPROVED	X	X
.XXX ±.005	.XX±.01	RELEASED	X	X
.XXXX ± .0005			SIGNATURE	DATE
ANGLES ± 1°-0'				

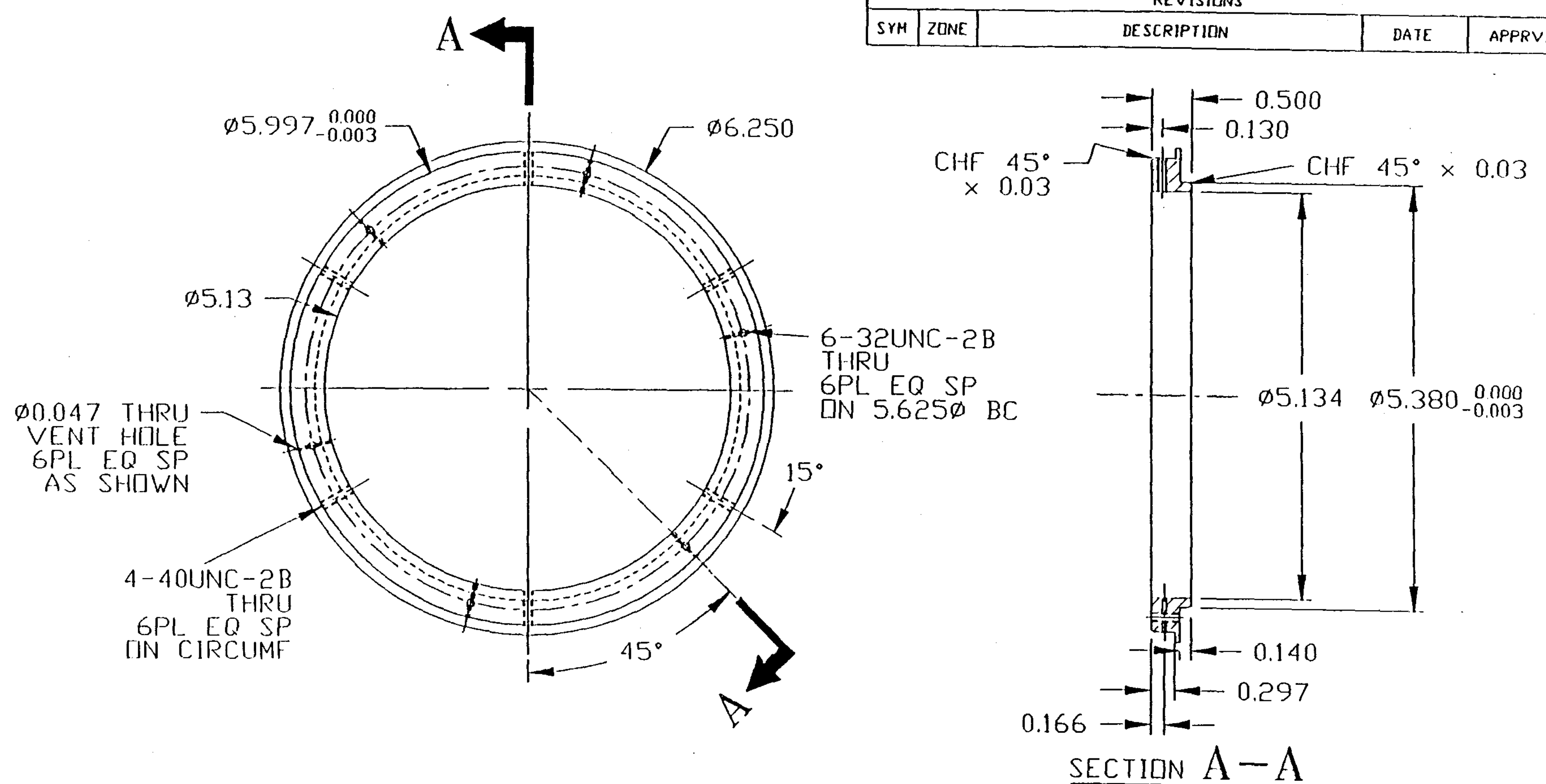
MATERIAL
ALUMINUM
6061-T6

FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

OUTER SHIELD
BASE PLATE
FOR MASER

PROJECT	SIZE	COMPUTER FILE OTRSHBAS.DWG	ISSUE
1190-3	A	MASR-0120	
SCALE 1=2	DO NOT SCALE PRINT	SHEET 1 OF 1	



REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.

TOLERANCES

ENGLISH ☒ INCHES
FRAC.±1/64
DECIMALS:
.XX ±.01
.XXX ±.005
.XXXX ± .0005

METRIC ☐ MILLIMETERS
DECIMALS:
.X ±.1
.XX±.01

ANGLES ± 1°-0'

DRAWN	TVP	3-28-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X
	SIGNATURE	DATE

MATERIAL
ALUMINUM
6061-T6

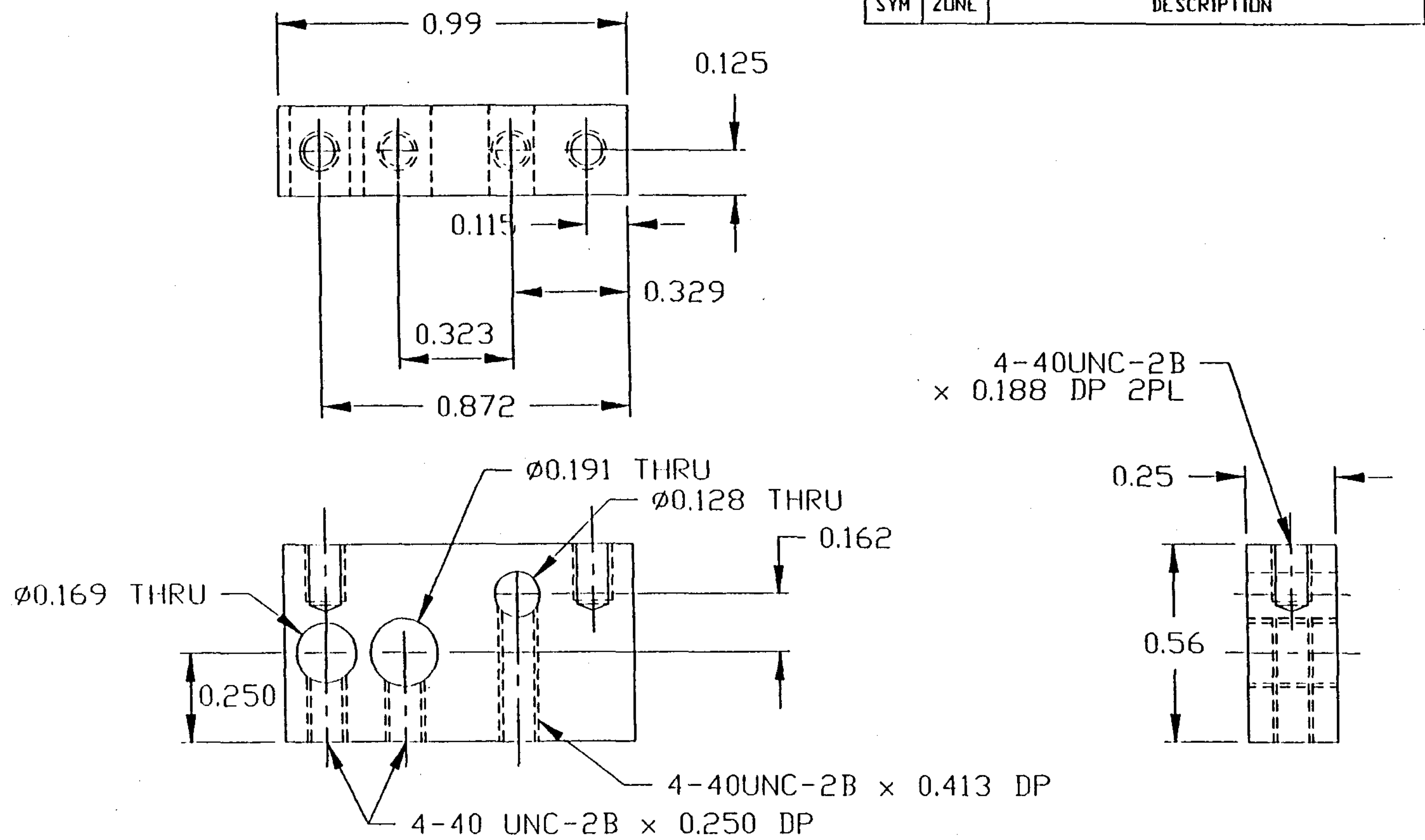
FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

OUTER SHIELD BASE PLATE FOR MASER

PROJECT	SIZE	COMPUTER FILE OTRSHBAS.DWG	ISSUE
1190-3	A	MASR-0120	
SCALE 1=2	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



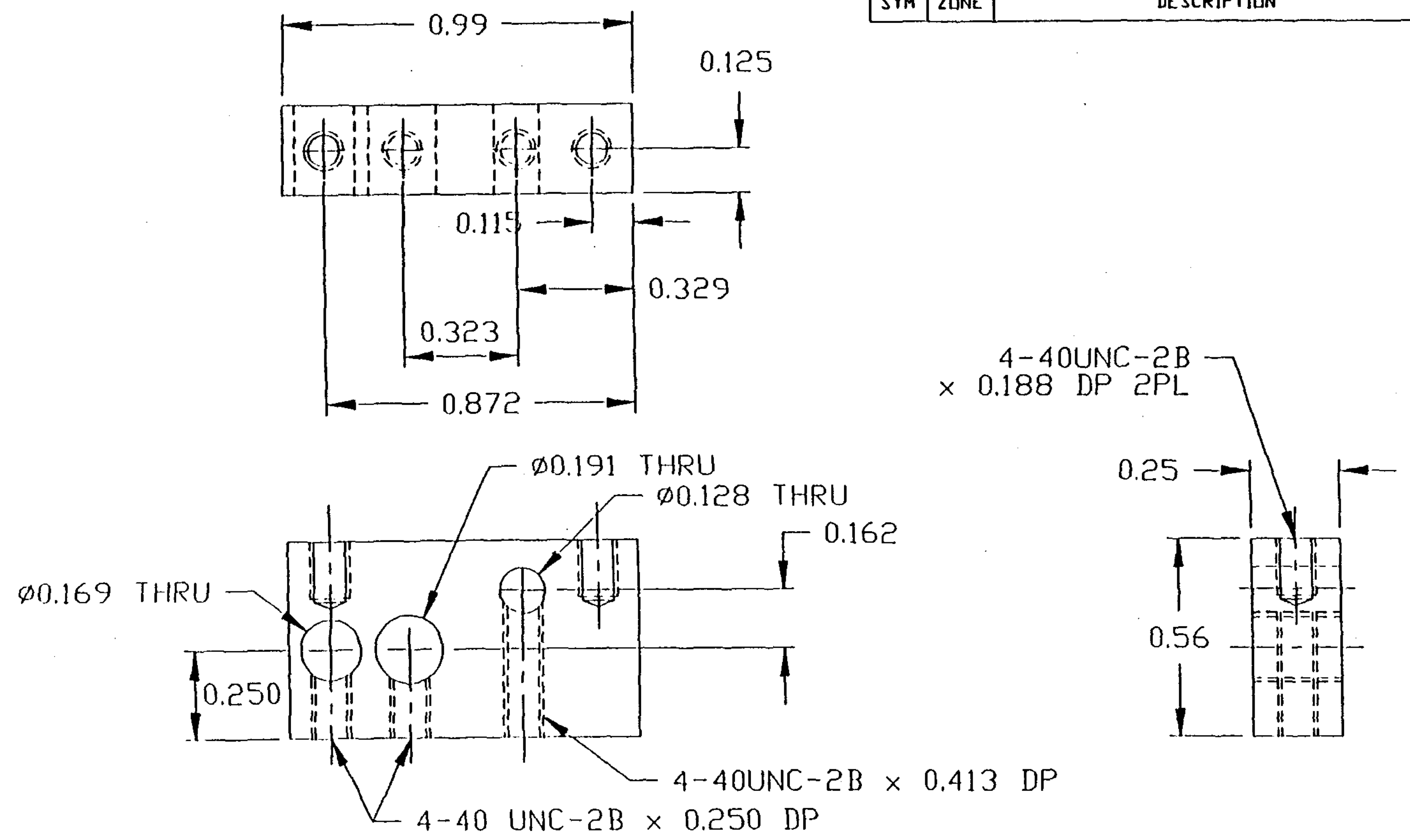
TOLERANCES	DRAWN	TVP	4-19-94
ENGLISH ☒ INCHES FRAC.±1/64 DECIMALS: .XX ±.01 .XXX ±.005 .XXXX ± .0005	CHECKED	X	X
METRIC ☐ MILLIMETERS DECIMALS: .X ±.1 .XX±.01	APPROVED	X	X
	APPROVED	X	X
	RELEASED	X	X
ANGLES ± 1°-0'		SIGNATURE	DATE
MATERIAL ALUMINUM 6061-T6	FINISH 32		

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

MOUNTING BRACKET
FOR MASER

PROJECT	SIZE	COMPUTER FILE MBRKT.DWG	ISSUE
1190-3	A	MASR-0099	
SCALE 2=1	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



TOLERANCES	
ENGLISH ☒	METRIC ☐
INCHES	MILLIMETERS
FRAC.±1/64	DECIMALS:
DECIMALS:	.X ±.1
.XX ±.01	.XX±.01
.XXX ±.005	
.XXXX ± .0005	
ANGLES ± 1°-0'	

MATERIAL
ALUMINUM
6061-T6

	SIGNATURE	DATE
DRAWN	TVP	4-19-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X

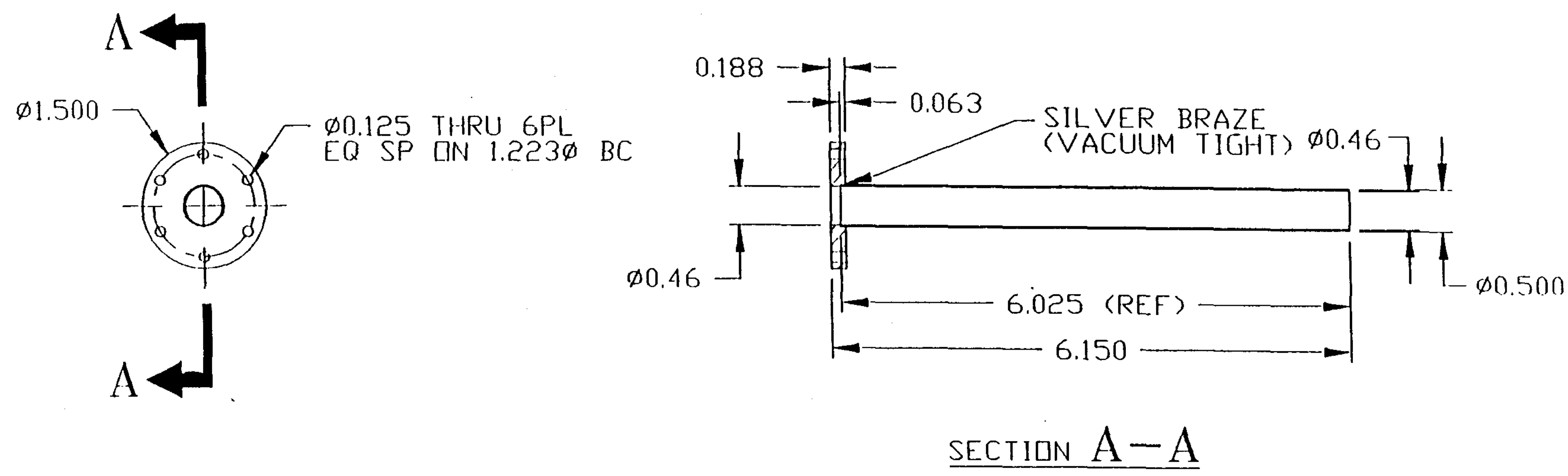
FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

MOUNTING BRACKET
FOR MASER

PROJECT	SIZE	COMPUTER FILE MBRKT.DWG	ISSUE
1190-3	A	MASR-0099	
SCALE 2=1	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



SECTION A–A

TOLERANCES		
ENGLISH ☒		METRIC ☐
INCHES		MILLIMETERS
FRAC.±1/64		DECIMALS:
DECIMALS:		.X ±.1
.XX ±.01		.XX±.01
.XXX ±.005		
.XXXX ± .0005		
ANGLES ± 1°-0'		

	SIGNATURE	DATE
DRAWN	TVP	6-9-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X

MATERIAL: STAINLESS STEEL

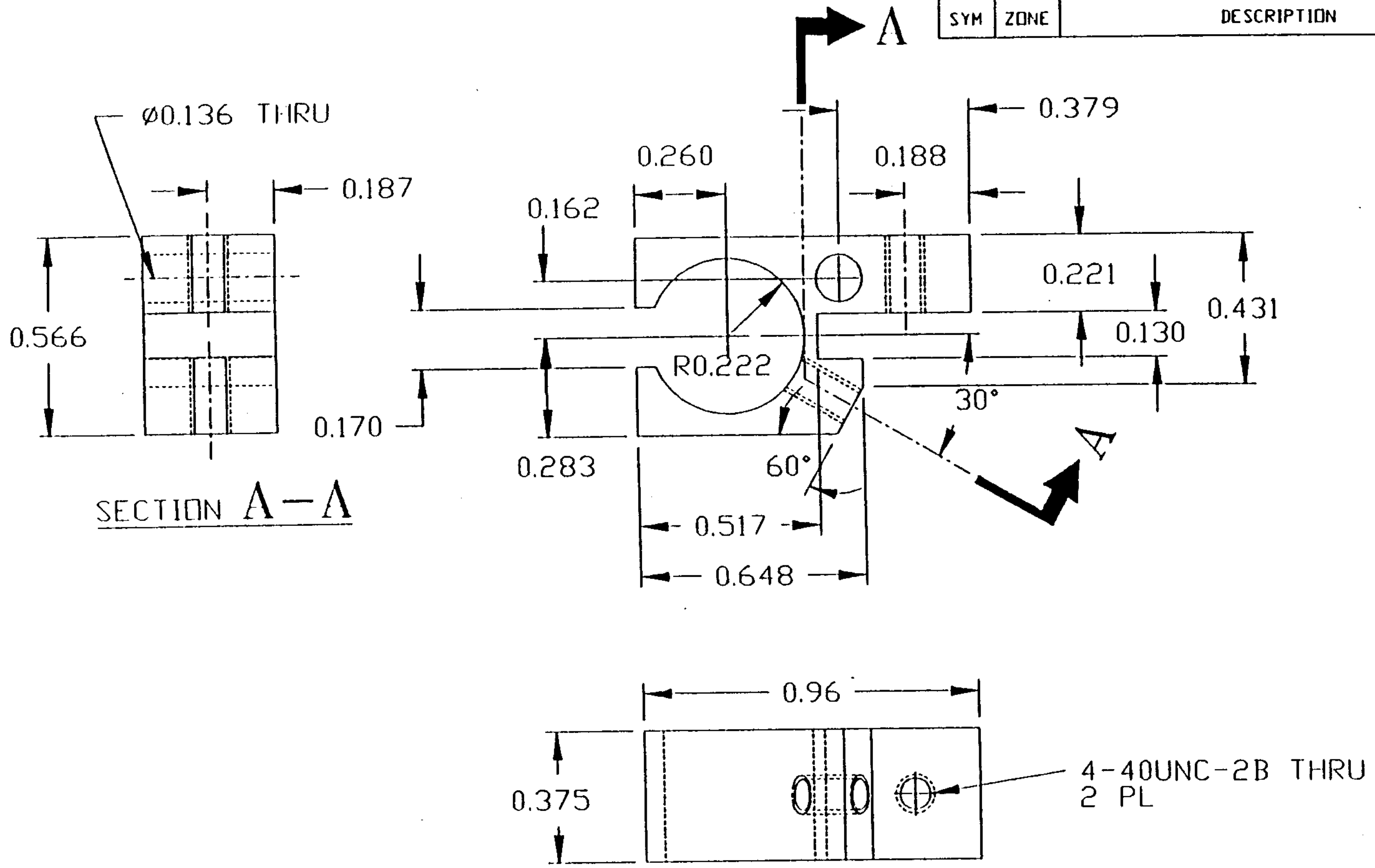
FINISH: 32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

FILL TUBE ASSEMBLY FOR MASER

PROJECT	SIZE	COMPUTER FILE FILTUBE.DWG	ISSUE
1190-3	A	MASR-0082	
SCALE 1=2	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



TOLERANCES	
ENGLISH ☒ INCHES	METRIC ☐ MILLIMETERS
FRAC.±1/64	DECIMALS:
DECIMALS:	.X ±.1
.XX ±.01	.XX±.01
.XXX ±.005	
.XXXX ± .0005	
ANGLES ± 1°-0'	

DRAWN	TVP	4-19-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X
	SIGNATURE	DATE

MATERIAL
ALUMINUM
6061-T6

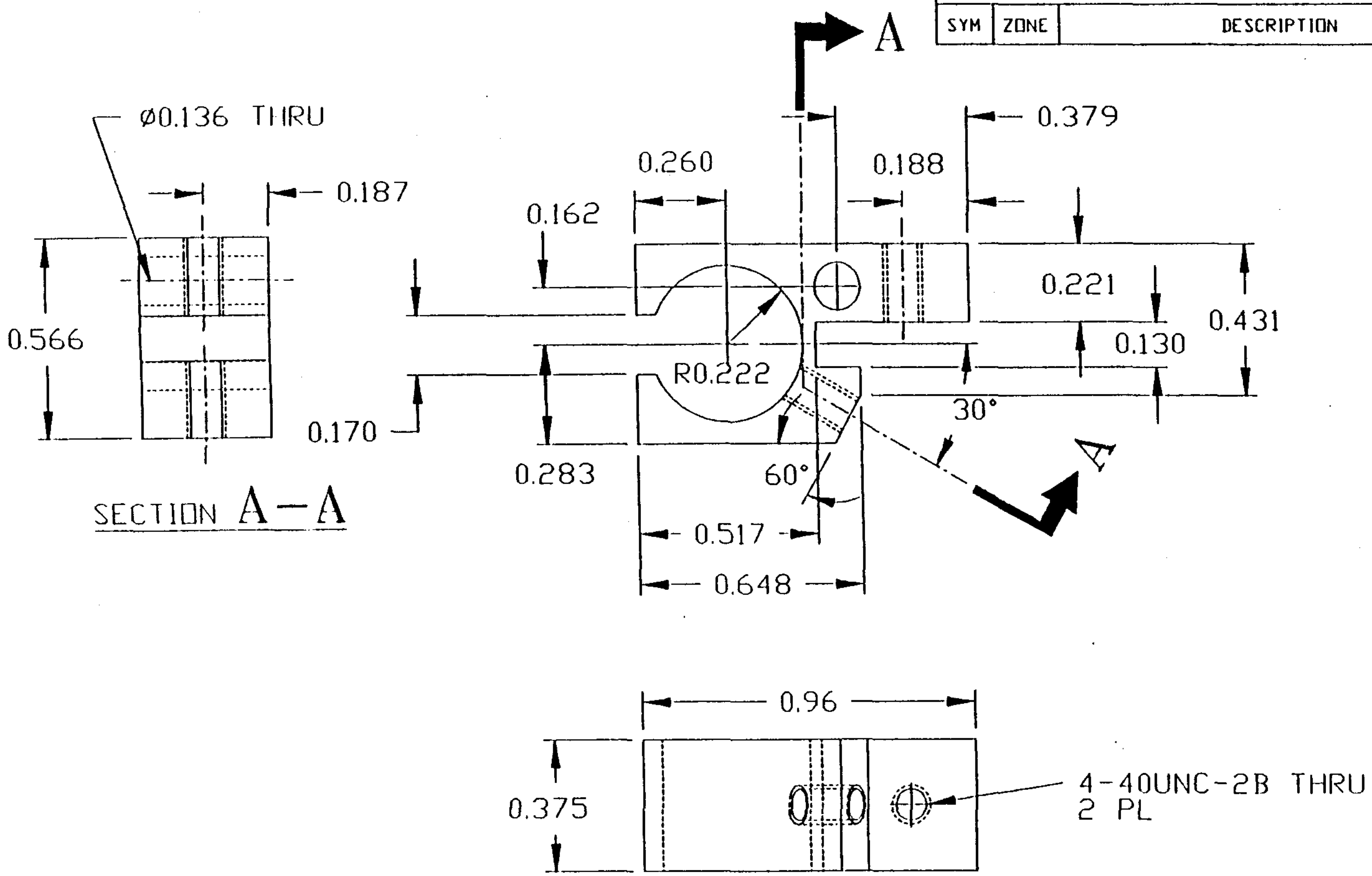
FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

MOTOR MOUNT
FOR MASER

PROJECT	SIZE	COMPUTER FILE MMOUNT.DWG	ISSUE
1190-3	A	MASR-0093	
SCALE 2=1	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



TOLERANCES

ENGLISH ☒ INCHES	METRIC ☐ MILLIMETERS
FRAC.±1/64	DECIMALS:
DECIMALS:	.X ±.1
.XX ±.01	.XX±.01
.XXX ±.005	
.XXXX ± .0005	

ANGLES ± 1°-0'

MATERIAL
ALUMINUM
6061-T6

DRAWN	TVP	4-19-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X
	SIGNATURE	DATE

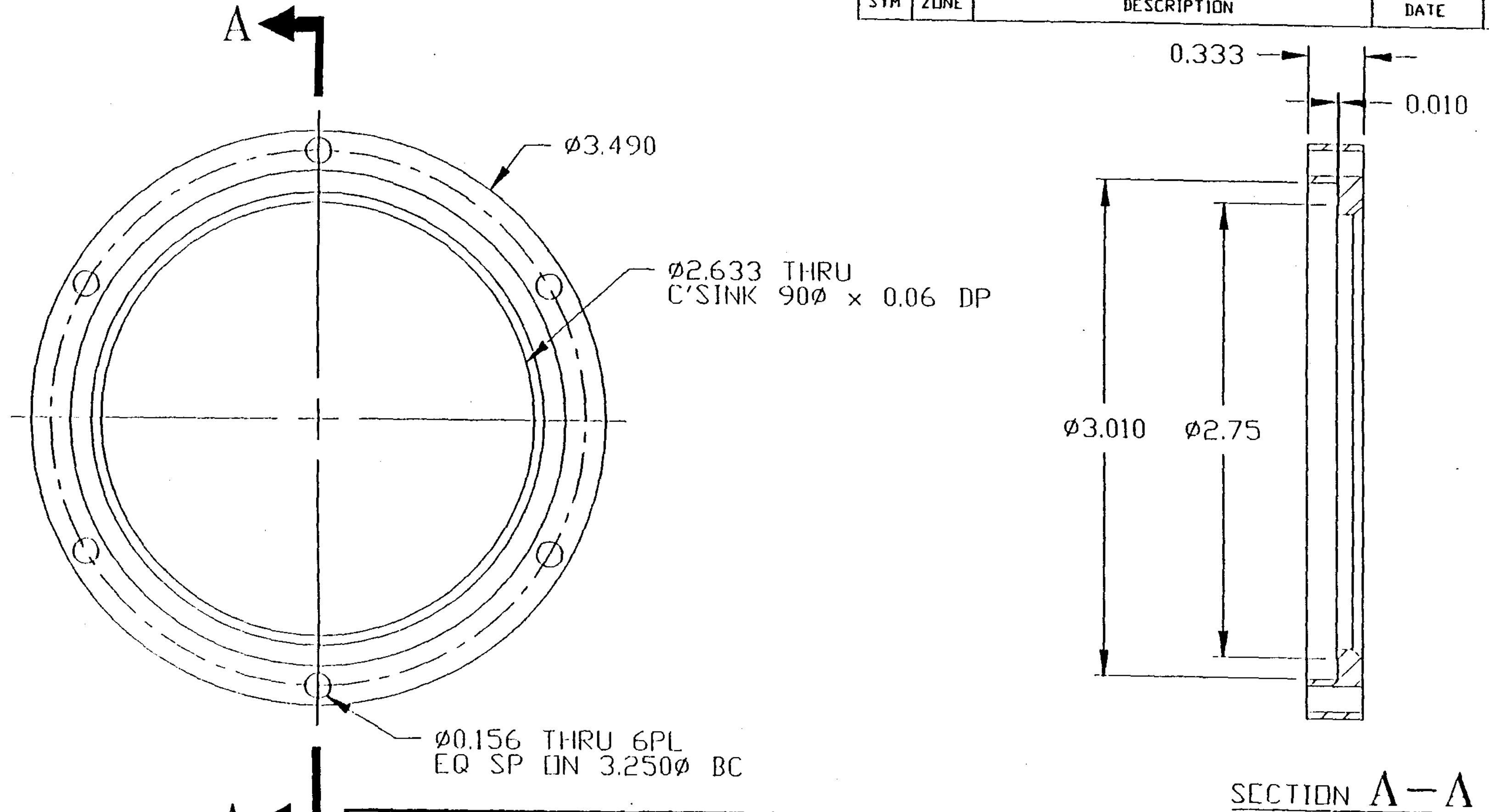
FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

MOTOR MOUNT
FOR MASER

PROJECT	SIZE	COMPUTER FILE MMOUNT.DWG	ISSUE
1190-3	A	MASR-0093	
SCALE 2=1	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



TOLERANCES	
ENGLISH ☒	METRIC ☐
INCHES	MILLIMETERS
FRAC.±1/64	
DECIMALS:	DECIMALS:
.XX ±.01	.X ±.1
.XXX ±.005	.XX±.01
.XXXX ± .0005	
ANGLES ± 1°-0'	

	SIGNATURE	DATE
DRAWN	TVP	6-8-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X

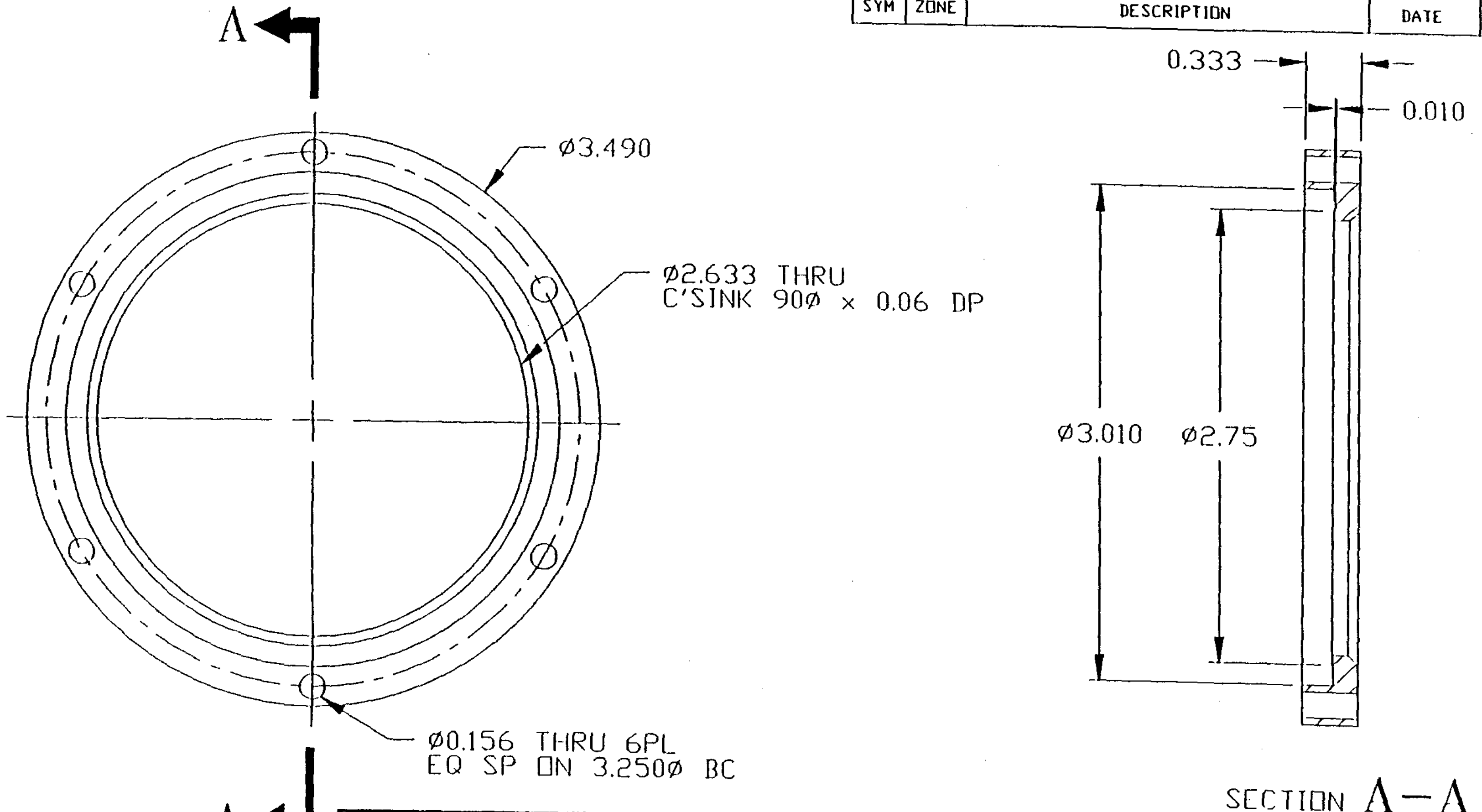
MATERIAL
ALUMINUM
6061-T6

FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

FILLPLATE CLAMP
FOR MASER

PROJECT	SIZE	COMPUTER FILE FILCLAMP.DWG	ISSUE
1190-3	A	MASR-0080	
SCALE 1=1	DO NOT SCALE PRINT	SHEET 1 OF 1	



REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.

DRAWN	TVP	6-8-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X
	SIGNATURE	DATE

TOLERANCES
ENGLISH ☒ INCHES
FRAC.±1/64
DECIMALS:
.XX ±.01
.XXX ±.005
.XXXX ± .0005
METRIC ☐ MILLIMETERS
DECIMALS:
.X ±.1
.XX±.01
ANGLES ± 1°-0'

MATERIAL
ALUMINUM
6061-T6

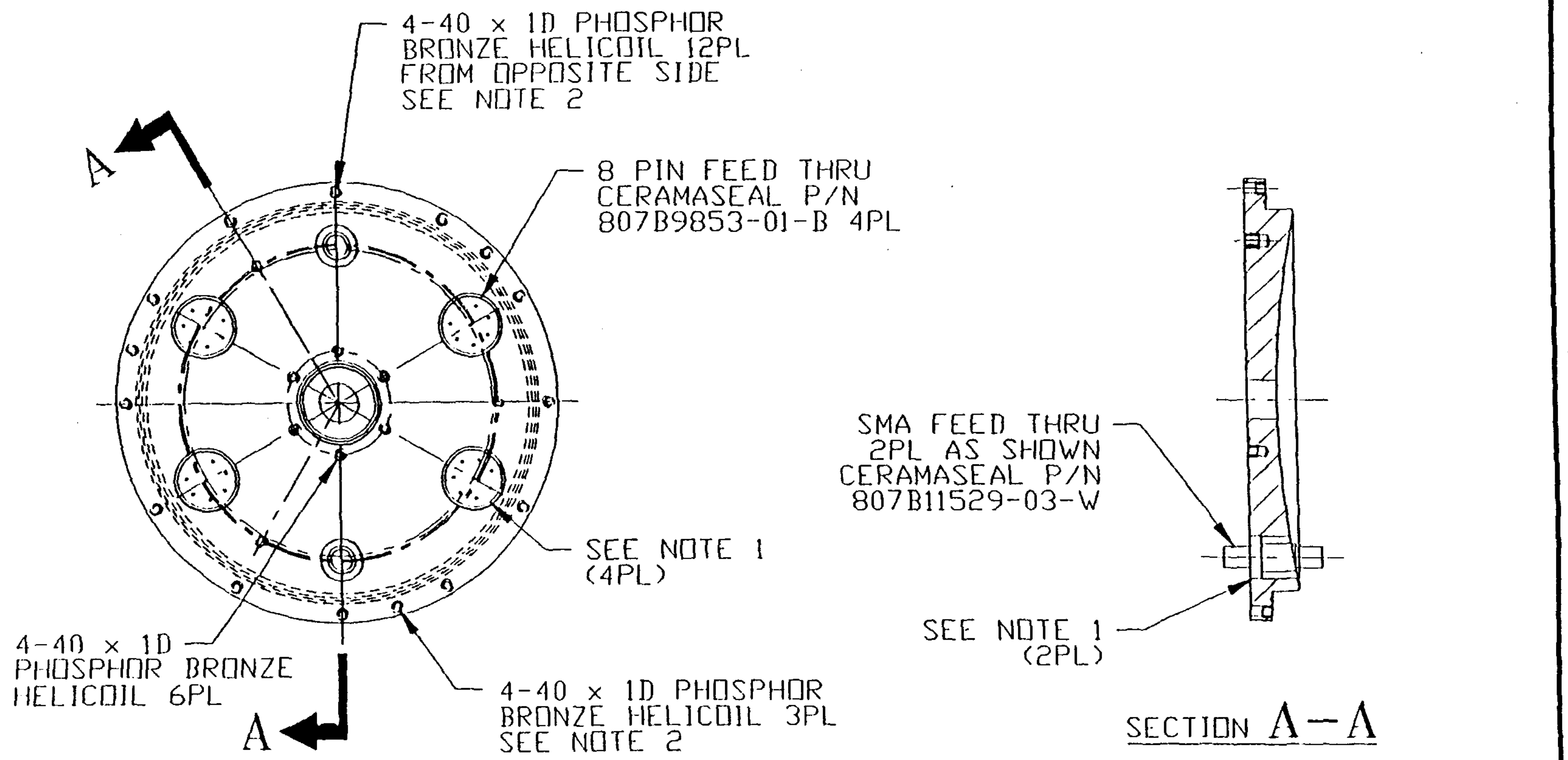
FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

FILLPLATE CLAMP
FOR MASER

PROJECT	SIZE	COMPUTER FILE FILCLAMP.DWG	ISSUE
1190-3	A	MASR-0080	
SCALE 1=1	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



NOTES:

1. HYDROGEN FURNACE BRAZE USING NICRO 80 ALLOY OR BETTER (HIGH VACUUM TIGHT)
2. INSTALL HELICOILS AFTER BRAZING

TOLERANCES	
ENGLISH ☒ INCHES	METRIC ☐ MILLIMETERS
FRAC.±1/64	DECIMALS:
DECIMALS:	.X ±.1
.XX ±.01	.XX±.01
.XXX ±.005	
.XXXX ± .0005	
ANGLES ± 1°-0'	

MATERIAL: OFHC COPPER

FINISH: 32

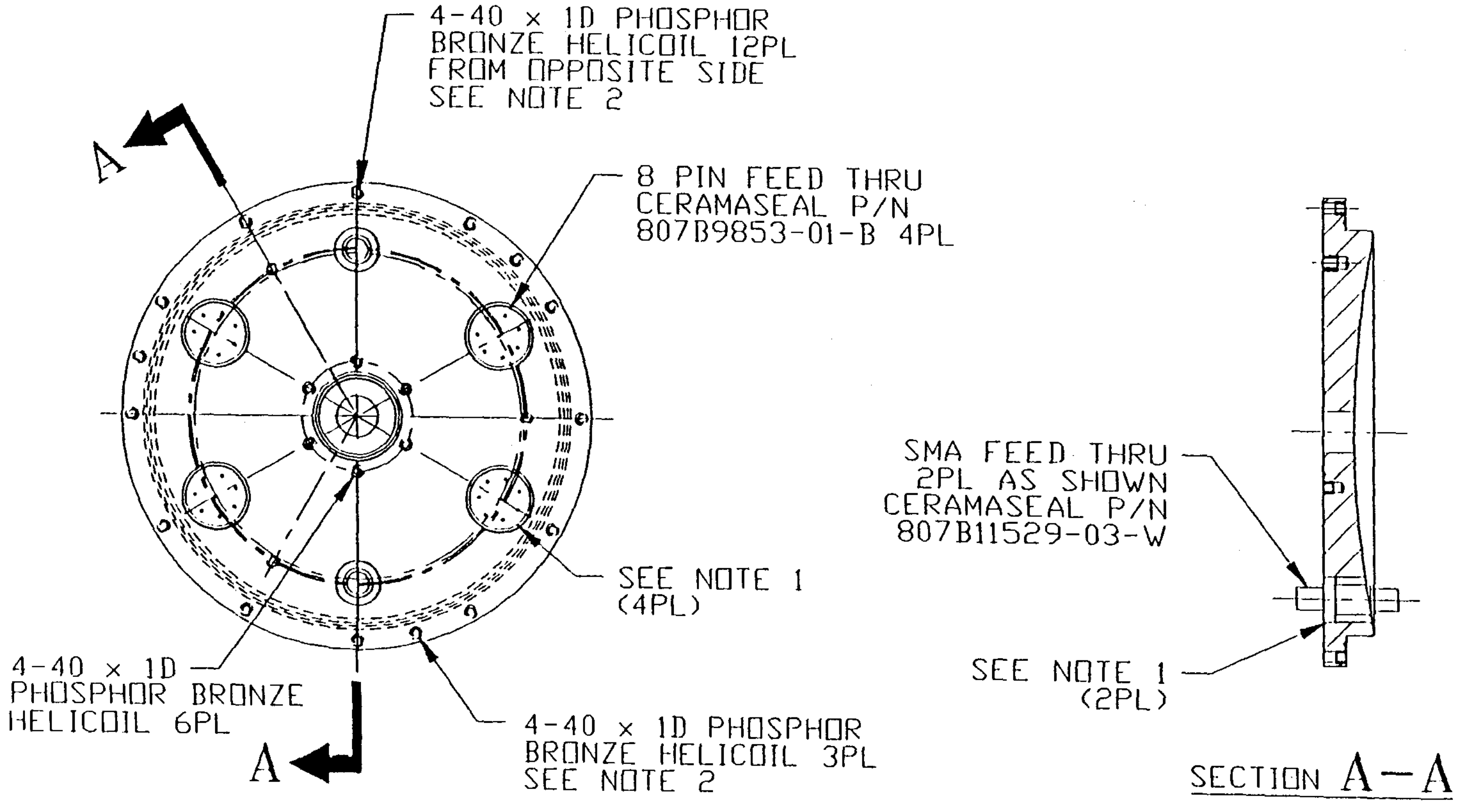
	SIGNATURE	DATE
DRAWN	TVP	7-12-94
CHECKED	GB	7-12-94
APPROVED	DO	7-12-94
APPROVED		
RELEASED		

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

CRYOSTAT COVER ASSEMBLY FOR MASER

PROJECT	SIZE	COMPUTER FILE CRYSTASY.DWG	ISSUE
1190-3	A	MASR-0062	
SCALE 1=2	DO NOT SCALE PRINT	SHEET 2 OF 2	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



NOTES:

1. HYDROGEN FURNACE BRAZE USING NICRO 80 ALLOY OR BETTER (HIGH VACUUM TIGHT)
2. INSTALL HELICOILS AFTER BRAZING

TOLERANCES

ENGLISH ☒	METRIC ☐
INCHES	MILLIMETERS
FRAC.±1/64	DECIMALS:
DECIMALS: .XX ±.01 .XXX ±.005 .XXXX ± .0005	.X ±.1 .XX±.01

ANGLES ± 1°-0'

	SIGNATURE	DATE
DRAWN	TVP	7-12-94
CHECKED	GB	7-12-94
APPROVED	DO	7-12-94
APPROVED		
RELEASED		

MATERIAL: OFHC COPPER

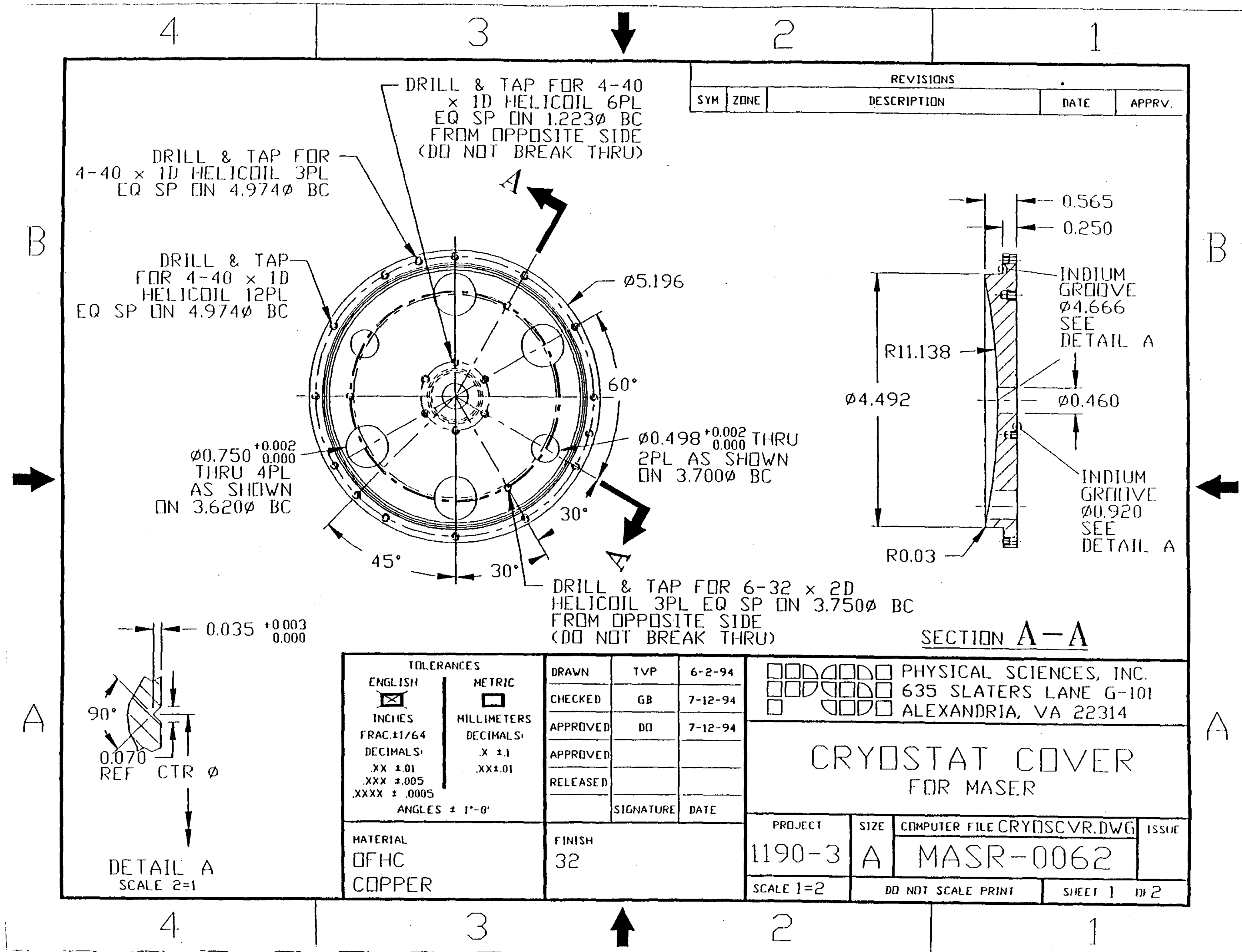
FINISH: 32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

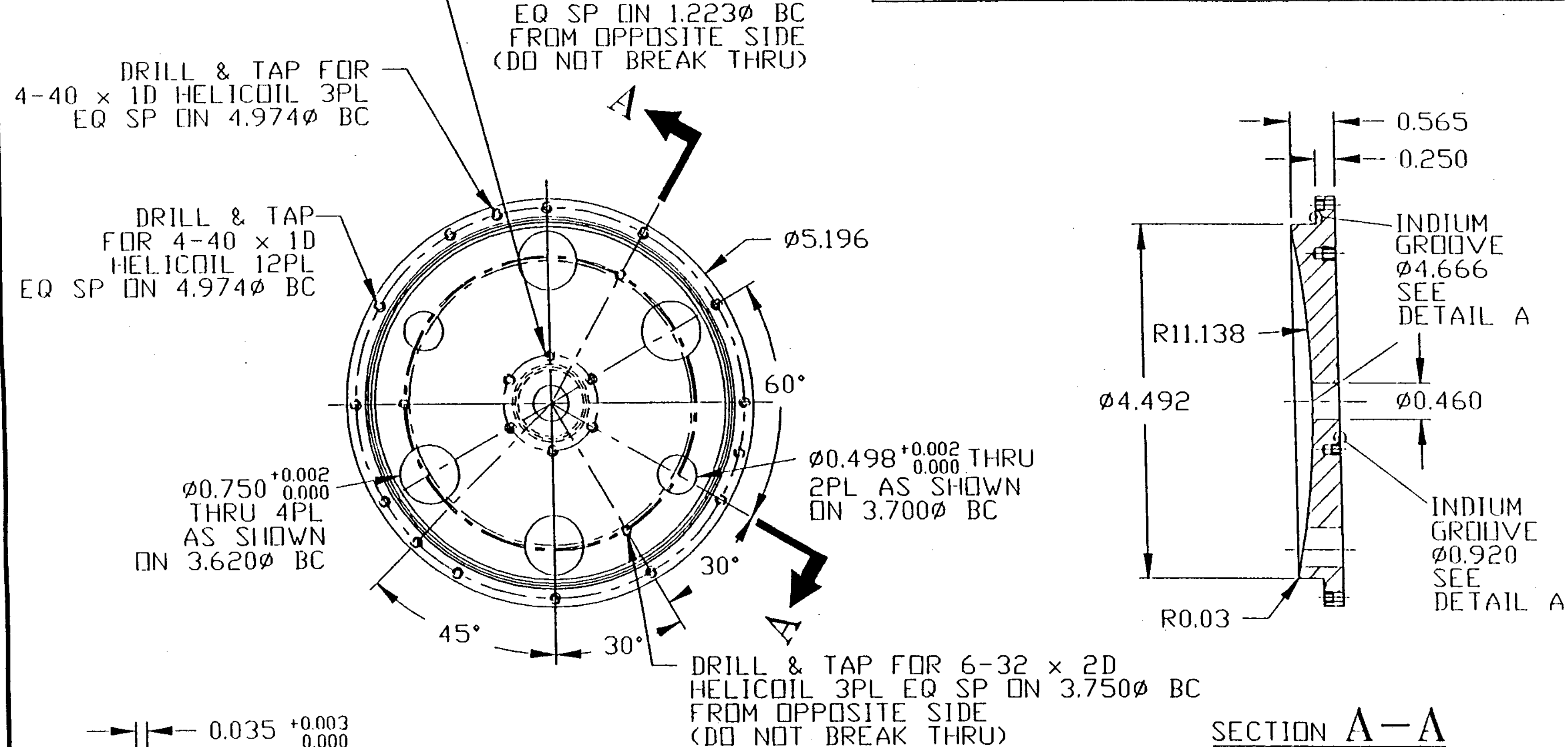
CRYOSTAT COVER ASSEMBLY FOR MASER

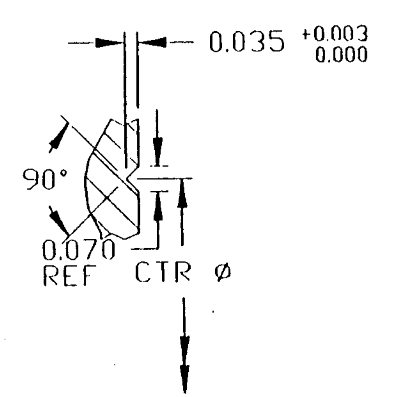
PROJECT	SIZE	COMPUTER FILE	ISSUE
1190-3	A	CRYSTASY.DWG MASR-0062	

SCALE 1=2 | DO NOT SCALE PRINT | SHEET 2 OF 2


REVISIONS
SYM | ZONE | DESCRIPTION | DATE | APPRV.
DRILL & TAP FOR 4-40 × 1D HELICOIL 6PL EQ SP ON 1.223Ø BC FROM OPPOSITE SIDE (DO NOT BREAK THRU)
DRILL & TAP FOR 4-40 × 1D HELICOIL 3PL EQ SP ON 4.974Ø BC
DRILL & TAP FOR 4-40 × 1D HELICOIL 12PL EQ SP ON 4.974Ø BC
Ø5.196
60°
Ø0.750 +0.002 0.000 THRU 4PL AS SHOWN ON 3.620Ø BC
Ø0.498 +0.002 0.000 THRU 2PL AS SHOWN ON 3.700Ø BC
30°
45°
30°
DRILL & TAP FOR 6-32 × 2D HELICOIL 3PL EQ SP ON 3.750Ø BC FROM OPPOSITE SIDE (DO NOT BREAK THRU)
A
A
0.565
0.250
INDIUM GROOVE Ø4.666 SEE DETAIL A
R11.138
Ø4.492
Ø0.460
INDIUM GROOVE Ø0.920 SEE DETAIL A
R0.03
SECTION A–A
0.035 +0.003 0.000
90°
0.070 REF
CTR Ø
DETAIL A
SCALE 2=1
TOLERANCES
ENGLISH
INCHES
FRAC.±1/64
DECIMALS:
.XX ±.01
.XXX ±.005
.XXXX ± .0005
METRIC
MILLIMETERS
DECIMALS:
.X ±.1
.XX±.01
ANGLES ± 1°-0'
DRAWN TVP 6-2-94
CHECKED GB 7-12-94
APPROVED DO 7-12-94
APPROVED
RELEASED
SIGNATURE DATE
MATERIAL
OFHC COPPER
FINISH
32
PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314
CRYOSTAT COVER
FOR MASER
PROJECT 1190-3
SIZE A
COMPUTER FILE CRYOSCVR.DWG
MASR-0062
ISSUE
SCALE 1=2
DO NOT SCALE PRINT
SHEET 1 OF 2

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.





DETAIL A
SCALE 2=1

TOLERANCES	
ENGLISH ☒ INCHES	METRIC ☐ MILLIMETERS
FRAC.±1/64	DECIMALS:
DECIMALS:	.X ±.1
.XX ±.01	.XX±.01
.XXX ±.005	
.XXXX ± .0005	
ANGLES ± 1°-0'	

DRAWN	TVP	6-2-94
CHECKED	GB	7-12-94
APPROVED	DO	7-12-94
APPROVED		
RELEASED		
	SIGNATURE	DATE

MATERIAL
OFHC COPPER

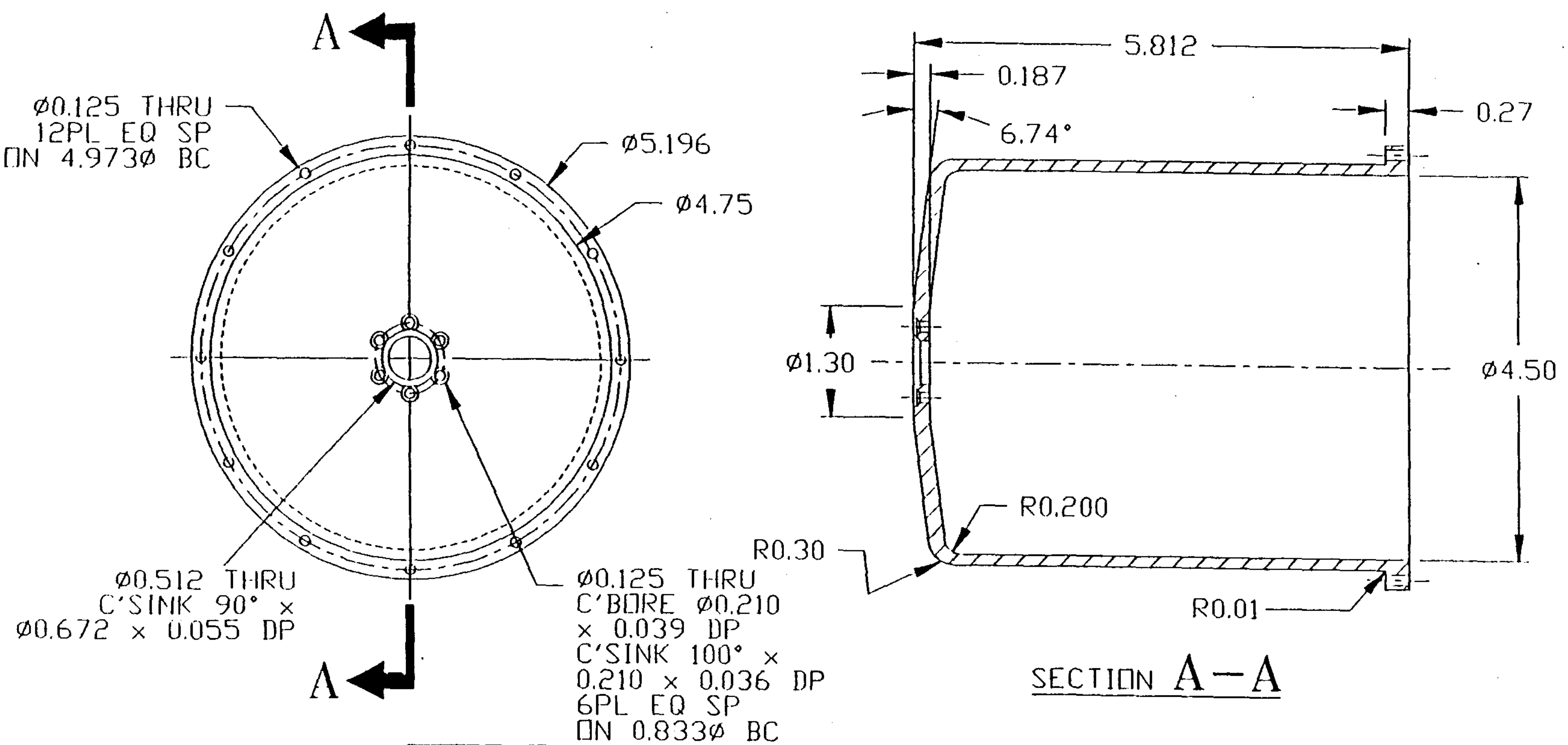
FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

CRYOSTAT COVER
FOR MASER

PROJECT	SIZE	COMPUTER FILE CRYOSCVR.DWG	ISSUE
1190-3	A	MASR-0062	
SCALE 1=2		DO NOT SCALE PRINT	SHEET 1 OF 2

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



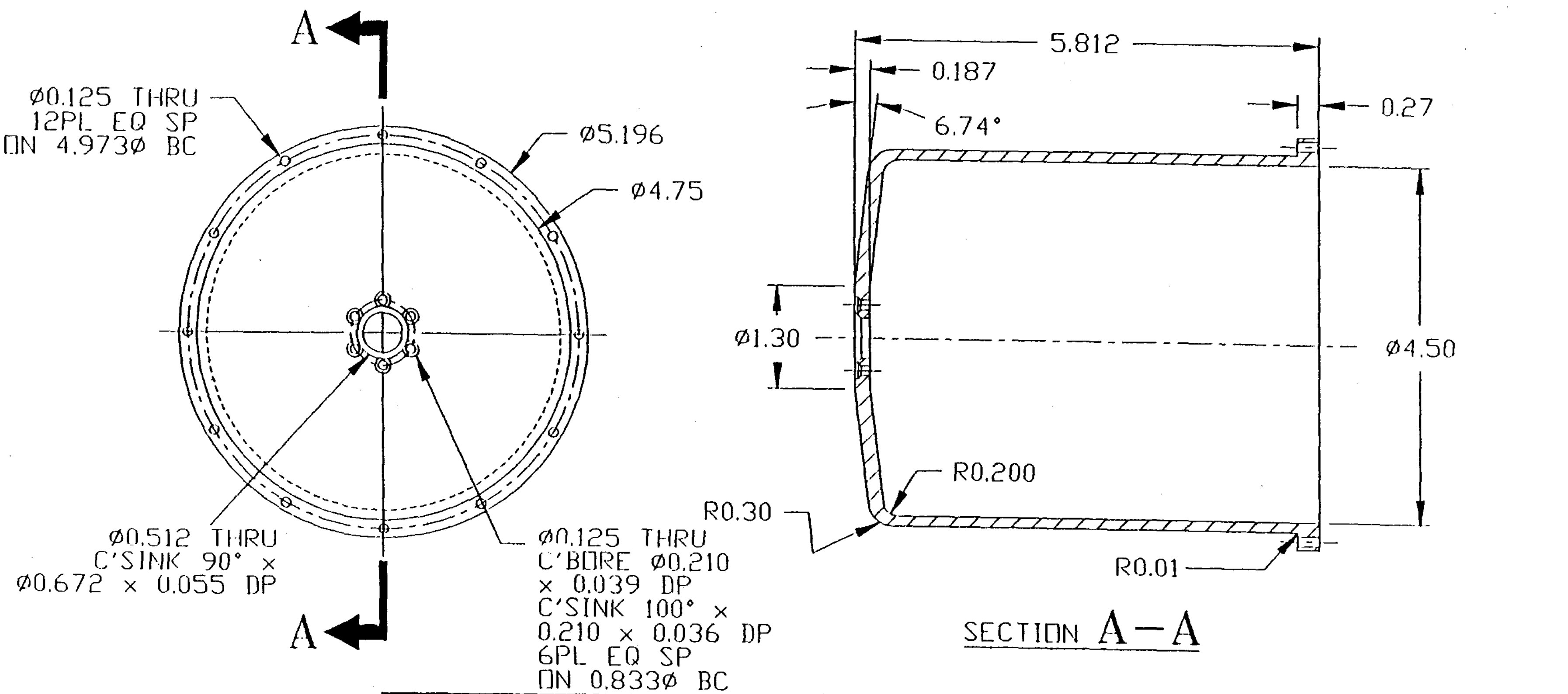
SECTION A—A

TOLERANCES				
ENGLISH ☒ INCHES	DRAWN	TVP	6-8-94	
FRAC.±1/64	CHECKED	X	X	
DECIMALS: .XX ±.01 .XXX ±.005 .XXXX ± .0005	APPROVED	X	X	
METRIC ☐ MILLIMETERS DECIMALS: .X ±.1 .XX±.01	APPROVED	X	X	
ANGLES ± 1°-0'	RELEASED	X	X	
		SIGNATURE	DATE	
MATERIAL BRASS	FINISH 32			

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

CRYOSTAT BODY
FOR MASER

PROJECT	SIZE	COMPUTER FILE CRYOSTT.DWG	ISSUE
1190-3	A	MASR-0061	
SCALE 1=2	DO NOT SCALE PRINT	SHEET 1 OF 1	



REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.

DRAWN	TVP	6-8-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X
	SIGNATURE	DATE

TOLERANCES
ENGLISH ☒ INCHES
FRAC. ±1/64
DECIMALS:
.XX ±.01
.XXX ±.005
.XXXX ± .0005
METRIC ☐ MILLIMETERS
DECIMALS:
.X ±.1
.XX±.01
ANGLES ± 1°-0'

MATERIAL
BRASS

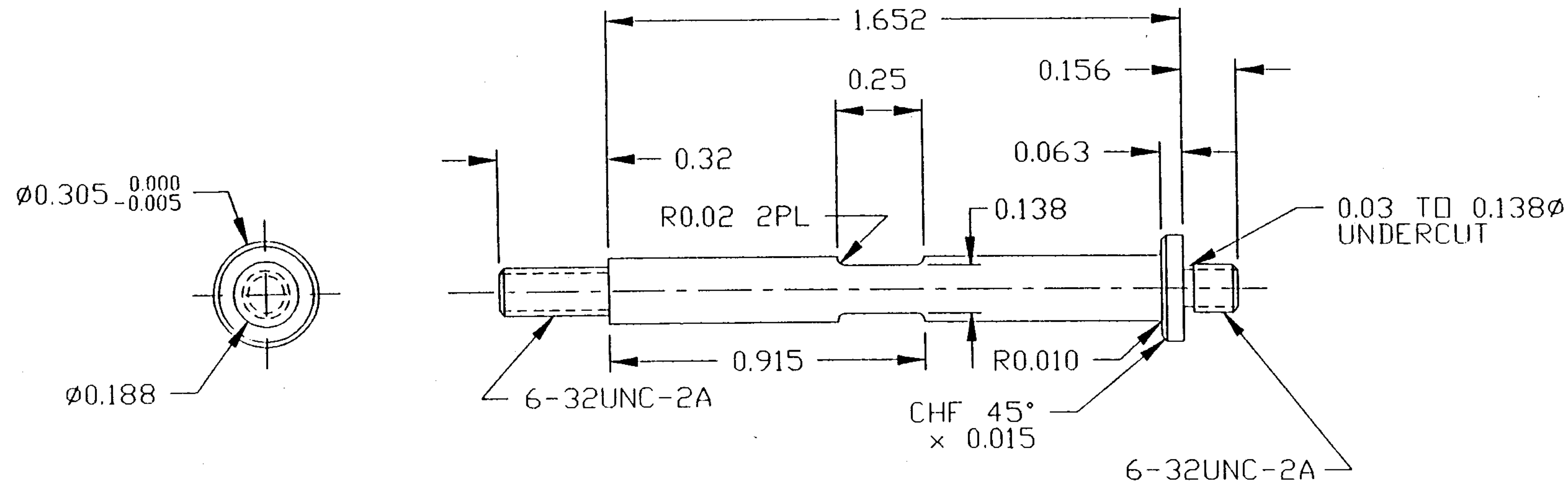
FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

CRYOSTAT BODY
FOR MASER

PROJECT	SIZE	COMPUTER FILE CRYOSTT.DWG	ISSUE
1190-3	A	MASR-0061	
SCALE 1=2		DO NOT SCALE PRINT	SHEET 1 OF 1

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



3 REQ'D

TOLERANCES

ENGLISH ☒ INCHES
FRAC.±1/64
DECIMALS:
.XX ±.01
.XXX ±.005
.XXXX ± .0005

METRIC ☐ MILLIMETERS
DECIMALS:
.X ±.1
.XX±.01

ANGLES ± 1°-0'

	SIGNATURE	DATE
DRAWN	TVP	4-25-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X

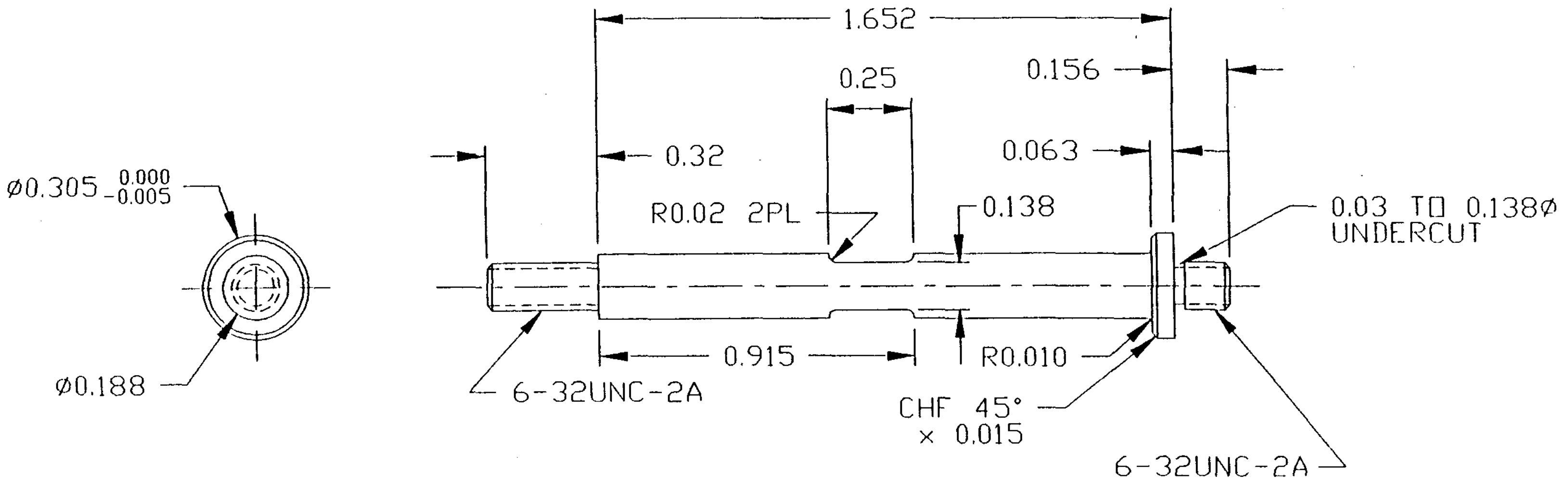
MATERIAL
STAINLESS STEEL
304 ALLOY

FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

COLUMN STUD
FOR MASER

PROJECT	SIZE	COMPUTER FILE COLMSTUD.DWG	ISSUE
1190-3	A	MASR-0053	
SCALE 2=1	DO NOT SCALE PRINT	SHEET 1 OF 1	

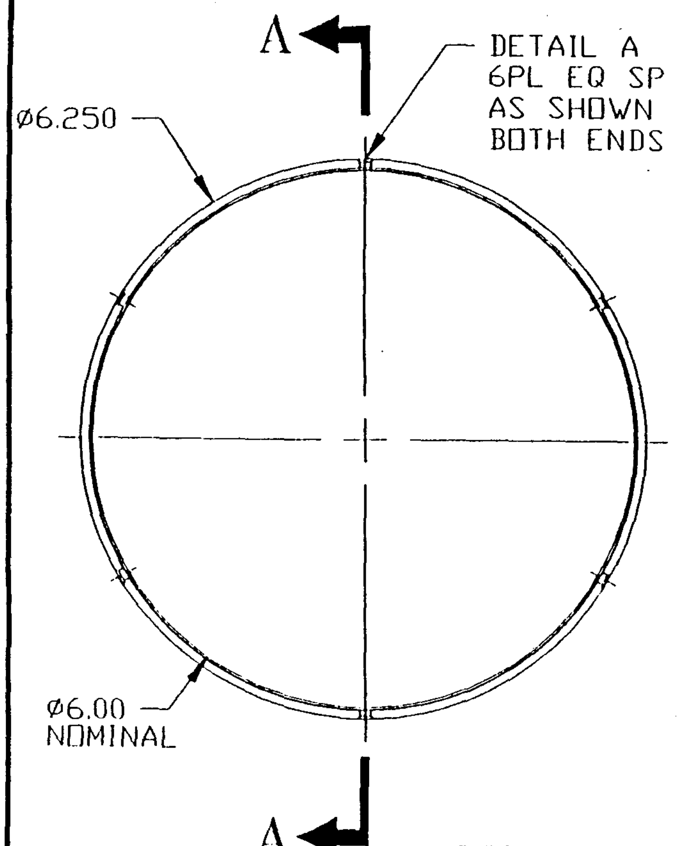


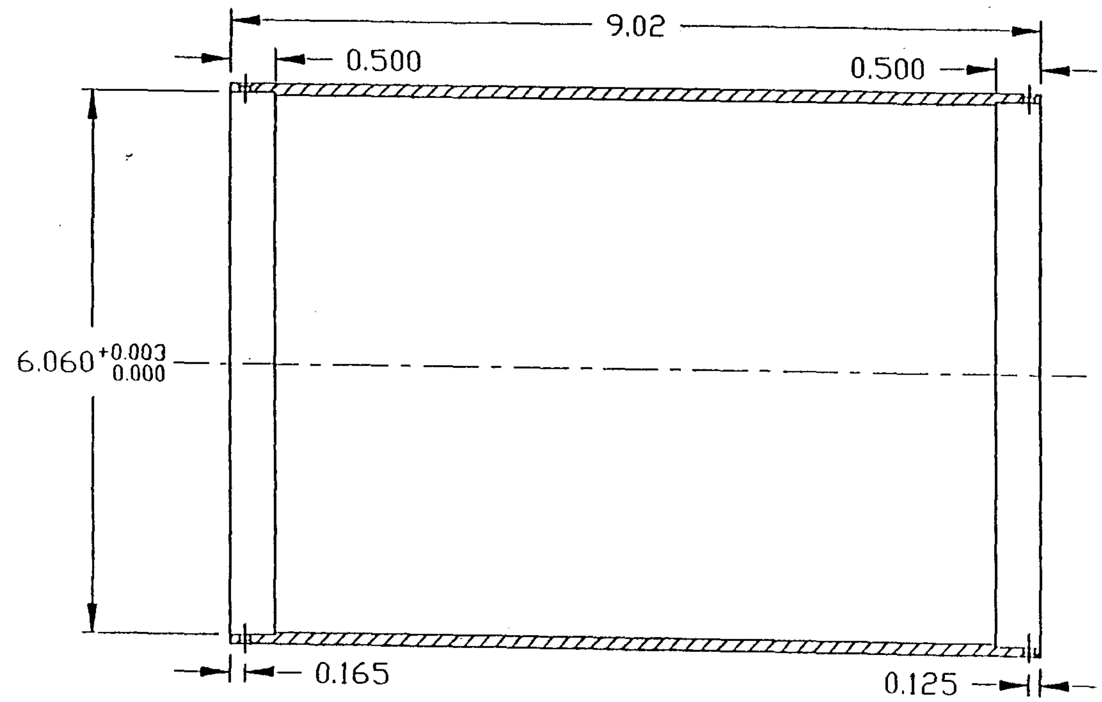
3 REQ'D

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.

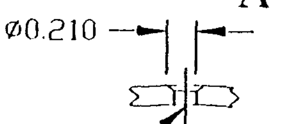
TOLERANCES ENGLISH [X] INCHES FRAC.±1/64 DECIMALS: .XX ±.01 .XXX ±.005 .XXXX ± .0005 METRIC [ ] MILLIMETERS DECIMALS: .X ±.1 .XX±.01 ANGLES ± 1°-0'	DRAWN TVP 4-25-94 CHECKED X X APPROVED X X APPROVED X X RELEASED X X SIGNATURE DATE	PHYSICAL SCIENCES, INC. 635 SLATERS LANE G-101 ALEXANDRIA, VA 22314	
MATERIAL STAINLESS STEEL 304 ALLOY	FINISH 32	COLUMN STUD FOR MASER	
		PROJECT 1190-3	SIZE A
		COMPUTER FILE COLMSTUD.DWG	ISSUE
		MASR-0053	
		SCALE 2=1	DO NOT SCALE PRINT
		SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.
A		.030 C'BORE ADDED & DETAIL A MOD.	4-5-95	TVP





SECTION A–A



DETAIL A
SCALE 1=1

TOLERANCES	
ENGLISH ☒ INCHES	METRIC ☐ MILLIMETERS
FRAC.±1/64	DECIMALS:
DECIMALS:	.X ±.1
.XX ±.01	.XX±.01
.XXX ±.005	
.XXXX ± .0005	
ANGLES ± 1°-0'	

DRAWN	TVP	3-18-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X
	SIGNATURE	DATE

MATERIAL
ALUMINUM
6061-T6

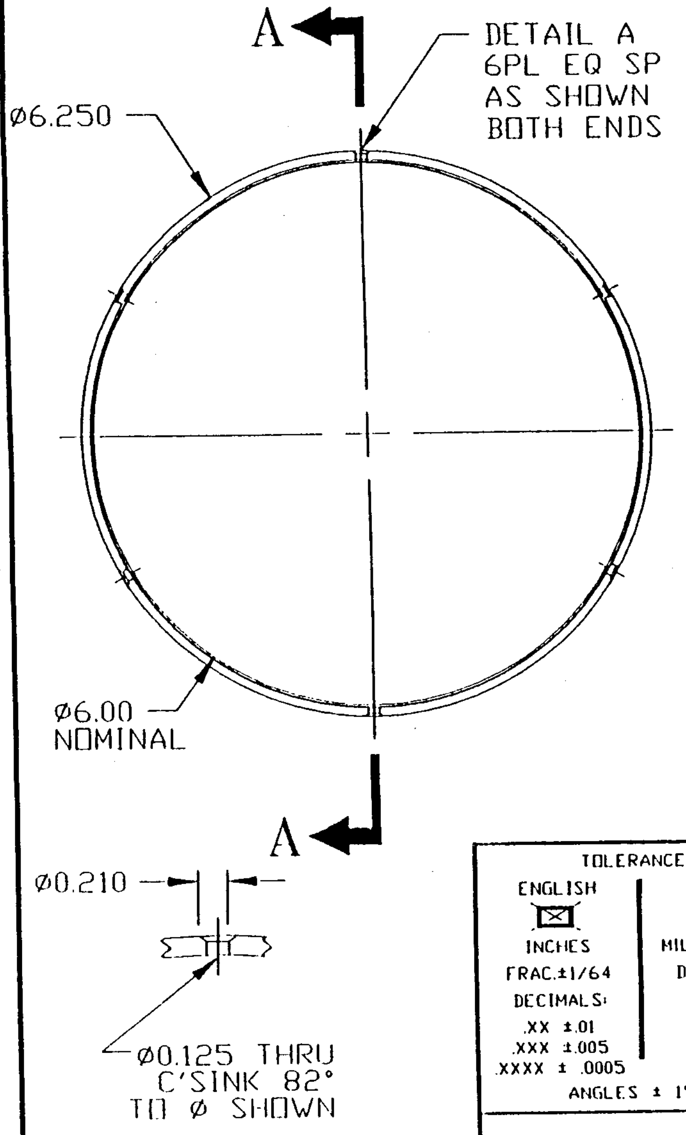
FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

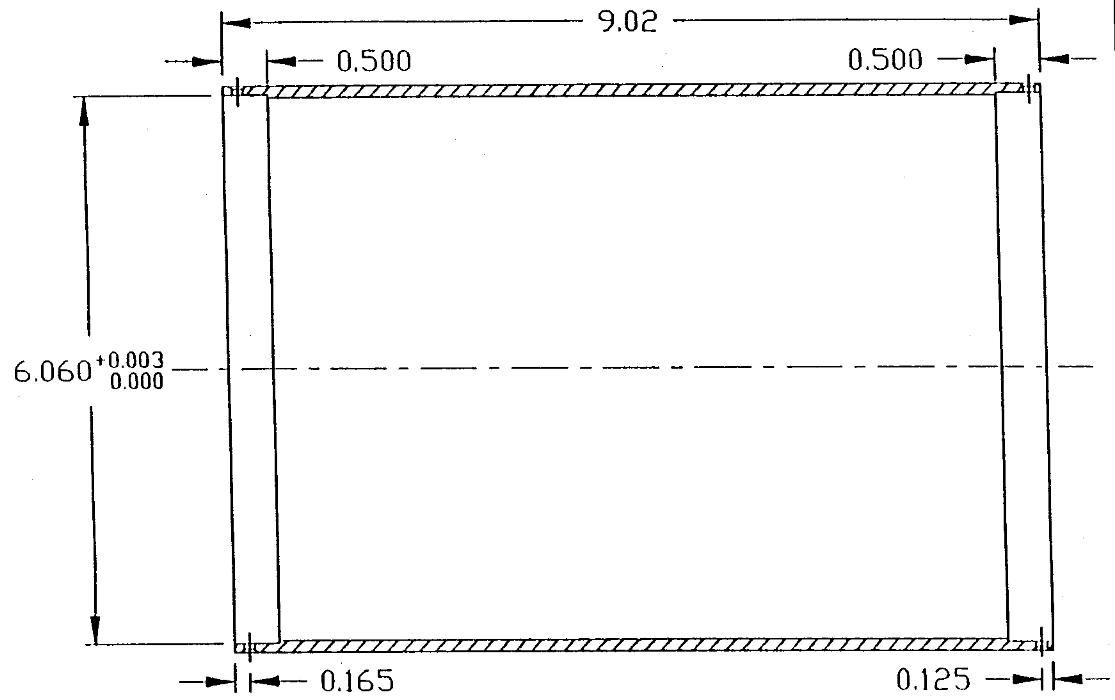
OUTER SHIELD
CYLINDER
FOR MASER

PROJECT	SIZE	COMPUTER FILE OTRSHCYL.DWG	ISSUE
1190-3	A	MASR-0122	A
SCALE 1=2		DO NOT SCALE PRINT	SHEET 1 OF 1

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.
A		.030 C'BORE ADDED & DETAIL A MOD.	4-5-95	TVP



DETAIL A
SCALE 1=1



SECTION A–A

TOLERANCES	
ENGLISH ☒	METRIC ☐
INCHES	MILLIMETERS
FRAC.±1/64	DECIMALS:
DECIMALS:	.X ±1
.XX ±.01	.XX±.01
.XXX ±.005	
.XXXX ± .0005	
ANGLES ± 1°-0'	

MATERIAL
ALUMINUM
6061-T6

DRAWN	TVP	3-18-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X
	SIGNATURE	DATE

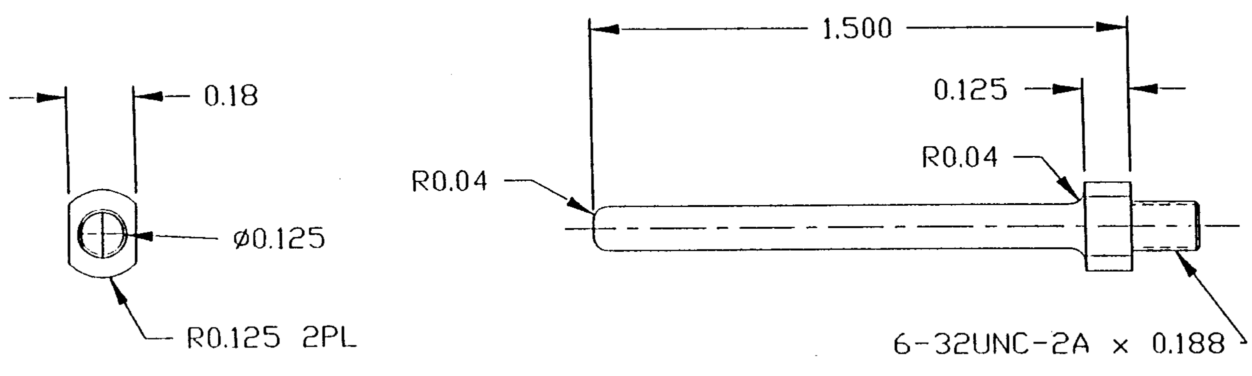
FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

OUTER SHIELD
CYLINDER
FOR MASER

PROJECT	SIZE	COMPUTER FILE OTRSHCYL.DWG	ISSUE
1190-3	A	MASR-0122	A
SCALE 1=2		DO NOT SCALE PRINT	SHEET 1 OF 1

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



4 REQ'D

TOLERANCES

ENGLISH ☒ INCHES
FRAC.±1/64
DECIMALS:
.XX ±.01
.XXX ±.005
.XXXX ± .0005

METRIC ☐ MILLIMETERS
DECIMALS:
.X ±.1
.XX±.01

ANGLES ± 1°-0'

MATERIAL
ALUMINUM
6061-T6

DRAWN	TVP	6-2-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X
	SIGNATURE	DATE

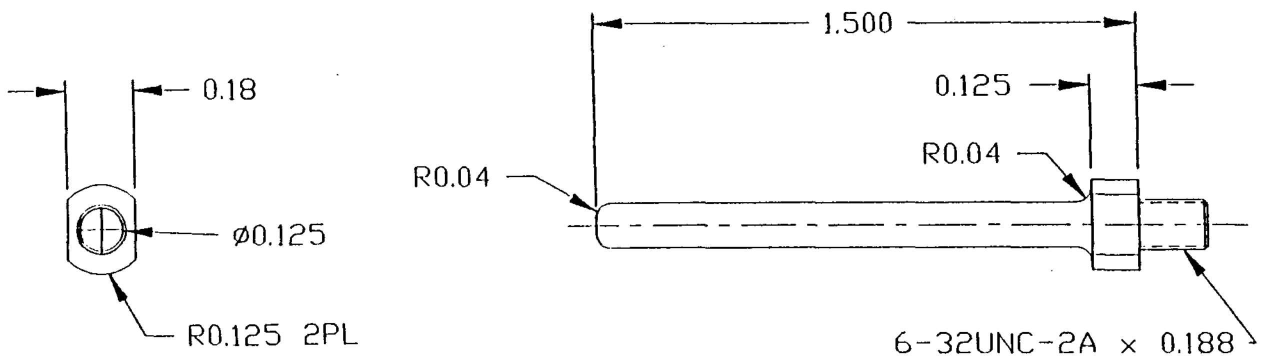
FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

POST
FOR MASER

PROJECT	SIZE	COMPUTER FILE POST.DWG	ISSUE
1190-3	A	MASR-0130	
SCALE 2=1	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



4 REQ'D

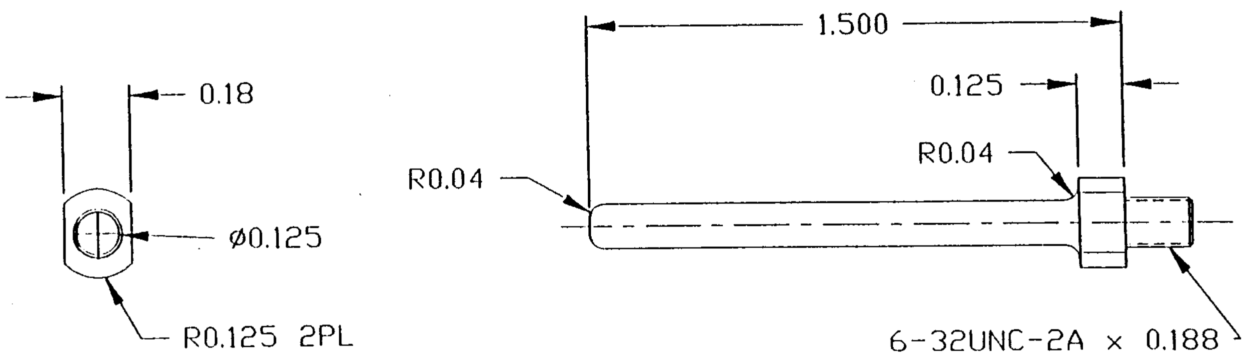
TOLERANCES ENGLISH ☒ INCHES FRAC.±1/64 DECIMALS: .XX ±.01 .XXX ±.005 .XXXX ± .0005 METRIC ☐ MILLIMETERS DECIMALS: .X ±.1 .XX±.01 ANGLES ± 1°-0'	DRAWN	TVP	6-2-94
	CHECKED	X	X
	APPROVED	X	X
	APPROVED	X	X
	RELEASED	X	X
		SIGNATURE	DATE
MATERIAL ALUMINUM 6061-T6	FINISH 32		

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

POST
FOR MASER

PROJECT	SIZE	COMPUTER FILE POST.DWG	ISSUE
1190-3	A	MASR-0130	
SCALE 2=1	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



4 REQ'D

TOLERANCES	
ENGLISH ☒	METRIC ☐
INCHES	MILLIMETERS
FRAC.±1/64	DECIMALS:
DECIMALS:	.X ±.1
.XX ±.01	.XX±.01
.XXX ±.005	
.XXXX ± .0005	
ANGLES ± 1°-0'	

DRAWN	TVP	6-2-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X
	SIGNATURE	DATE

MATERIAL
ALUMINUM
6061-T6

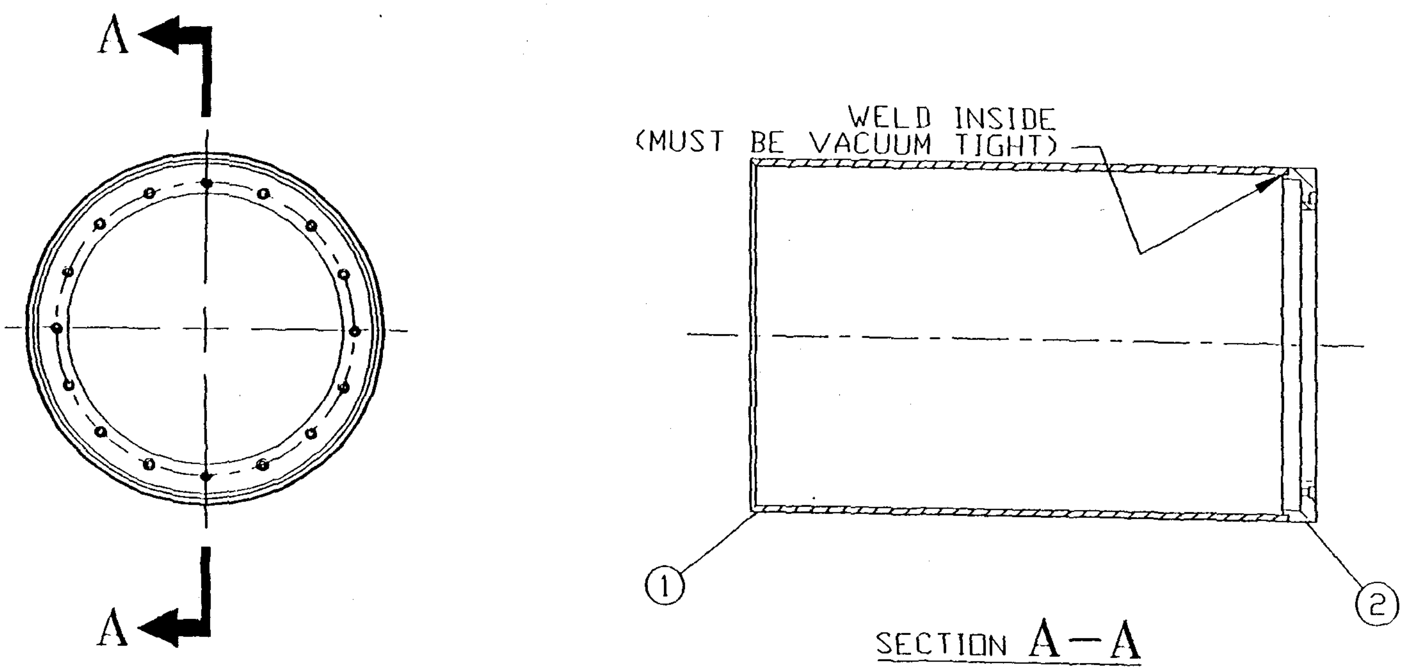
FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

POST
FOR MASER

PROJECT	SIZE	COMPUTER FILE POST.DWG	ISSUE
1190-3	A	MASR-0130	
SCALE 2=1	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



2	MASR-0134	VACUUM ENCLOSURE TOP
1	MASR-0133	VACUUM ENCLOSURE CYLINDER

TOLERANCES

ENGLISH ☒	METRIC ☐
INCHES	MILLIMETERS
FRAC.±1/64	DECIMALS:
DECIMALS:	.X ±.1
.XX ±.01	.XX±.01
.XXX ±.005	
.XXXX ± .0005	

ANGLES ± 1°-0'

MATERIAL
ALUMINUM
6061-T6

	SIGNATURE	DATE
DRAWN	TVP	5-19-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X

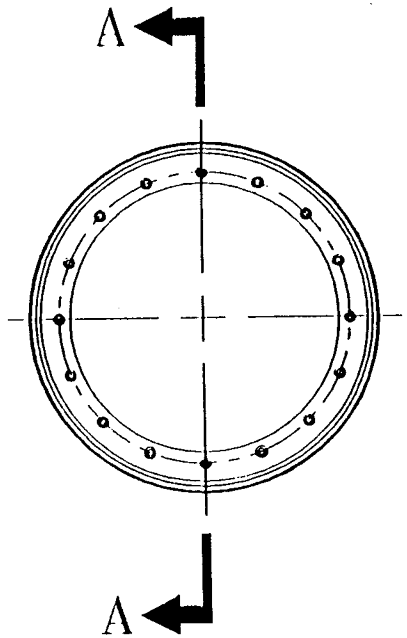
FINISH
32

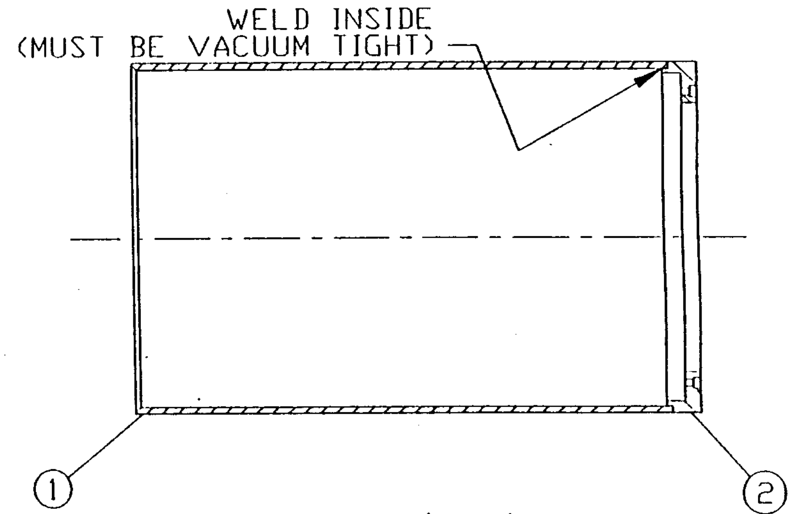
PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

VACUUM ENCLOSURE
ASSEMBLY
FOR MASER

PROJECT	SIZE	COMPUTER FILE VACENCLS.DWG	ISSUE
1190-3	A	MASR-0131	
SCALE 1=4	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.





SECTION A—A

2	MASR-0134	VACUUM ENCLOSURE TOP
1	MASR-0133	VACUUM ENCLOSURE CYLINDER

TOLERANCES

ENGLISH ☒	METRIC ☐
INCHES	MILLIMETERS
FRAC.±1/64	DECIMALS:
DECIMALS:	.X ±.1
.XX ±.01	.XX±.01
.XXX ±.005	
.XXXX ± .0005	

ANGLES ± 1°-0'

MATERIAL
ALUMINUM
6061-T6

DRAWN	TVP	5-19-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X
	SIGNATURE	DATE

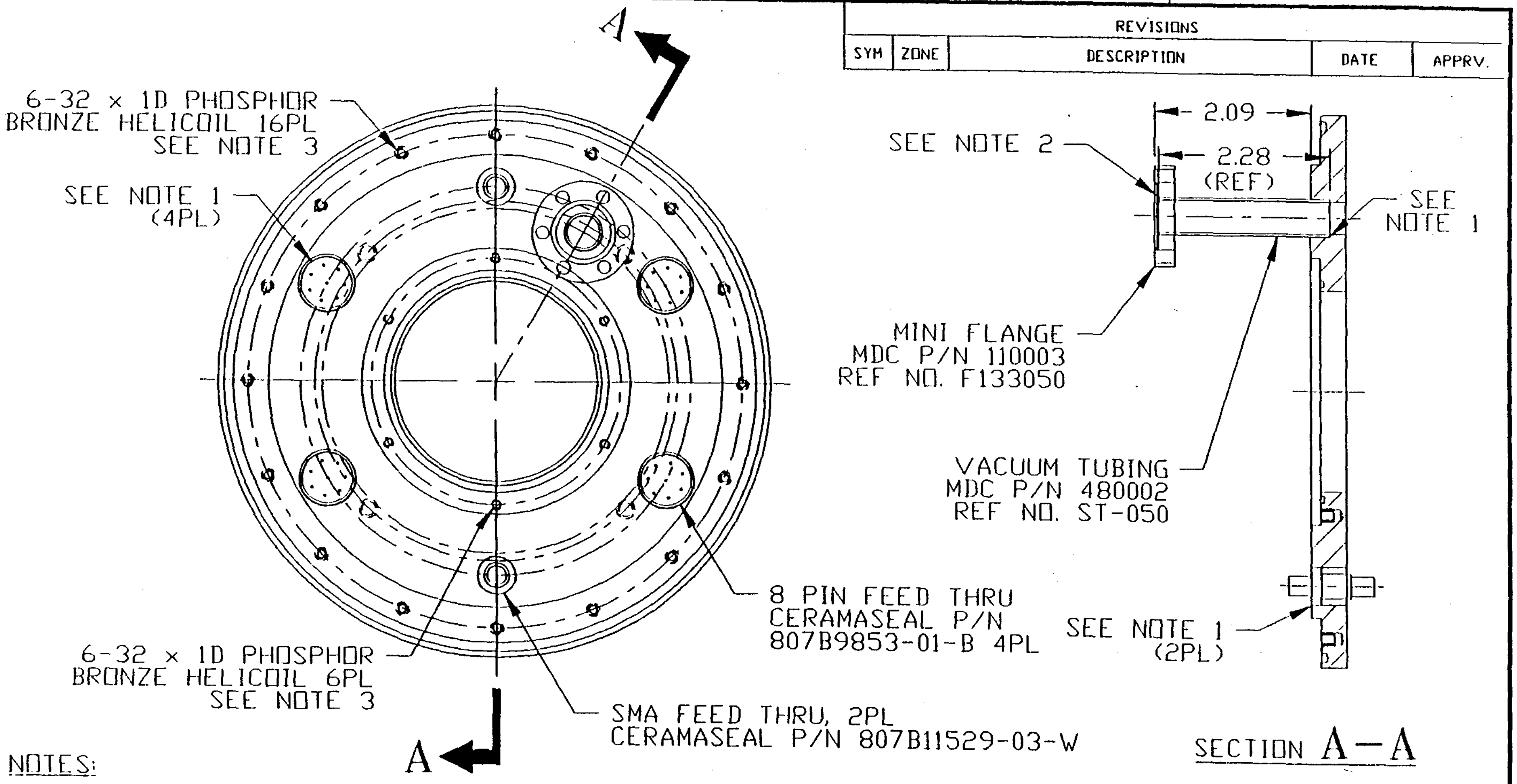
FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

VACUUM ENCLOSURE
ASSEMBLY
FOR MASER

PROJECT	SIZE	COMPUTER FILE VACENCLS.DWG	ISSUE
1190-3	A	MASR-0131	
SCALE 1=4	DO NOT SCALE PRINT		SHEET 1 OF 1

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



NOTES:

1. HYDROGEN FURNACE BRAZE USING NICRO 80 ALLOY OR BETTER (HIGH VACUUM TIGHT)
2. FUSE WELD FLANGE AFTER BRAZING (HIGH VACUUM TIGHT)
3. INSERT HELICOILS AFTER BRAZING

TOLERANCES	
ENGLISH ☒ INCHES	METRIC ☐ MILLIMETERS
FRAC.±1/64	
DECIMALS: .XX ±.01 .XXX ±.005 .XXXX ± .0005	DECIMALS: .X ±.1 .XX±.01
ANGLES ± 1°-0'	

MATERIAL
OFHC COPPER

DRAWN	TVP	6-30-94
CHECKED	GB	7-12-94
APPROVED	DO	7-14-94
APPROVED		
RELEASED		
	SIGNATURE	DATE

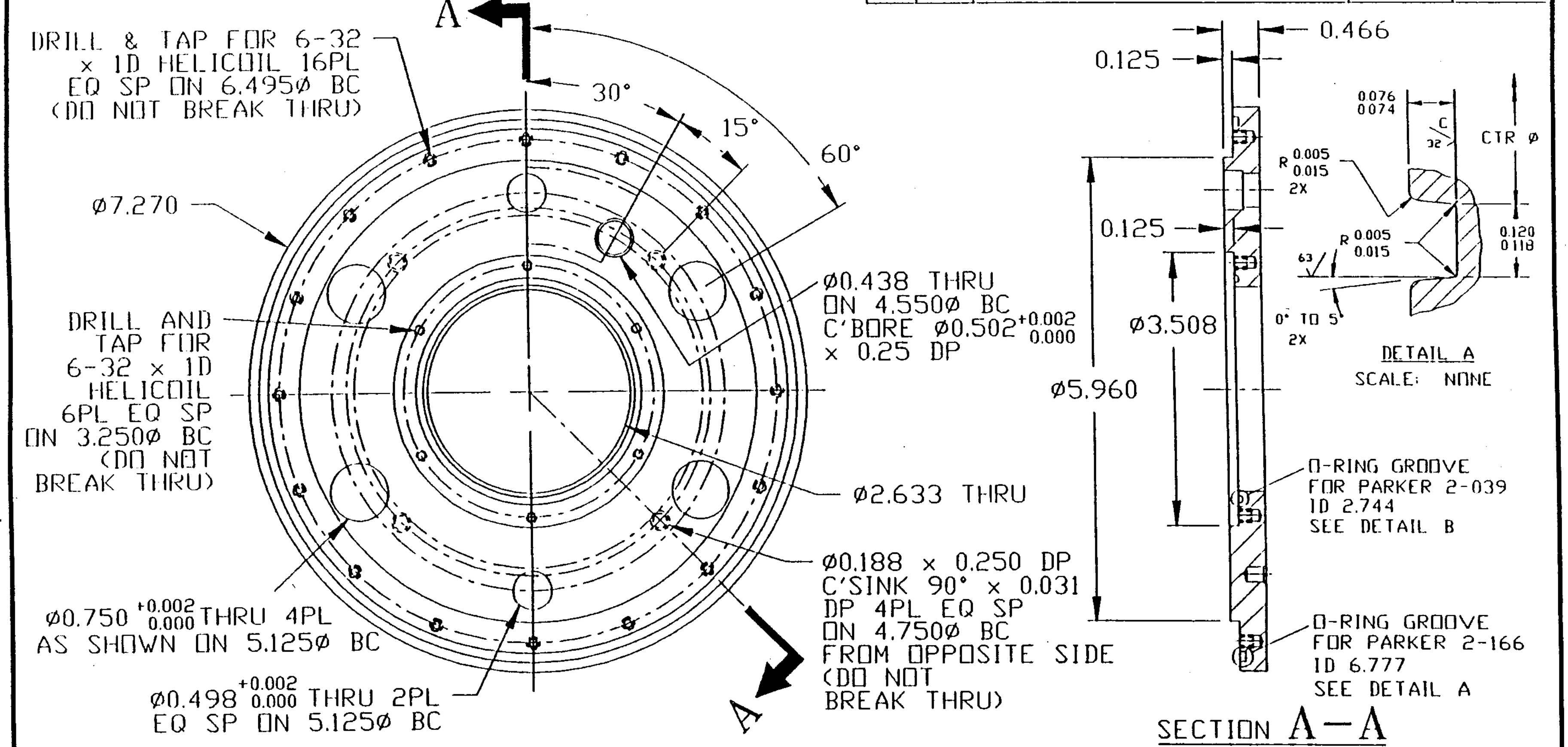
FINISH
32

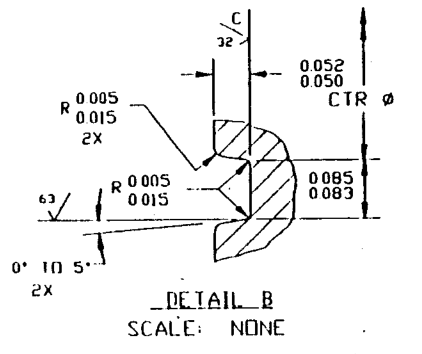
PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

VACUUM ENCLOSURE COVER ASSEMBLY
FOR MASER

PROJECT	SIZE	COMPUTER FILE VACVRASY.DWG	ISSUE
1190-3	A	MASR-0132	
SCALE 1=2	DO NOT SCALE PRINT	SHEET 2 OF 2	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.





TOLERANCES	
ENGLISH ☒ INCHES	METRIC ☐ MILLIMETERS
FRAC. ±1/64	
DECIMALS: .XX ±.01 .XXX ±.005 .XXXX ± .0005	DECIMALS: .X ±.1 .XX±.01
ANGLES ± 1°-0'	

MATERIAL
OFHC COPPER

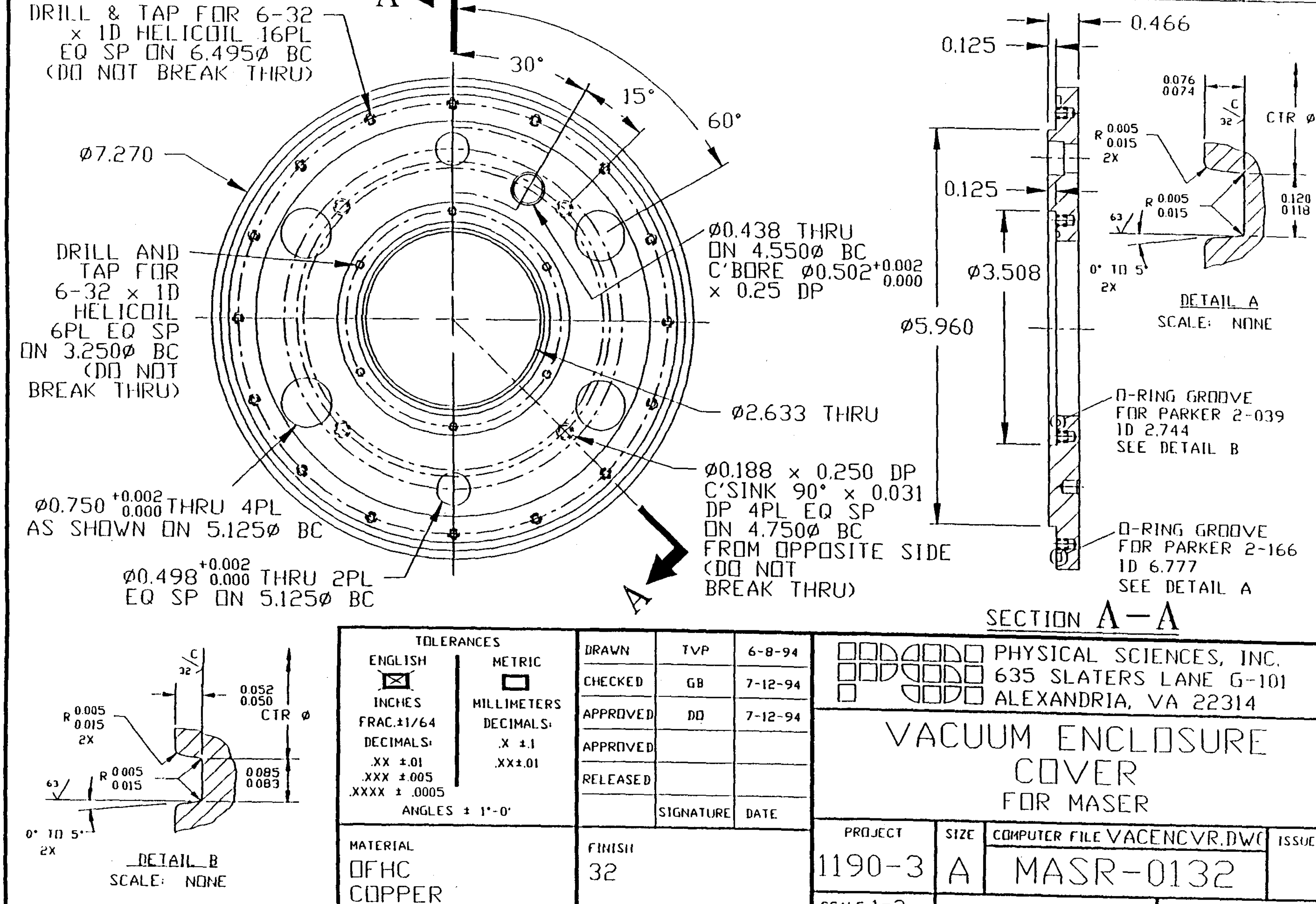
DRAWN	TVP	6-8-94
CHECKED	GB	7-12-94
APPROVED	DO	7-12-94
APPROVED		
RELEASED		
	SIGNATURE	DATE

FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

VACUUM ENCLOSURE COVER FOR MASER

PROJECT	SIZE	COMPUTER FILE VACENCVR.DWG	ISSUE
1190-3	A	MASR-0132	
SCALE 1=2		DO NOT SCALE PRINT	SHEET 1 OF 2



TOLERANCES	
ENGLISH ☒ INCHES	METRIC ☐ MILLIMETERS
FRAC.±1/64	DECIMALS:
DECIMALS: .XX ±.01 .XXX ±.005 .XXXX ± .0005	.X ±.1 .XX±.01
ANGLES ± 1°-0'	

DRAWN	TVP	6-8-94
CHECKED	GB	7-12-94
APPROVED	DO	7-12-94
APPROVED		
RELEASED		
	SIGNATURE	DATE

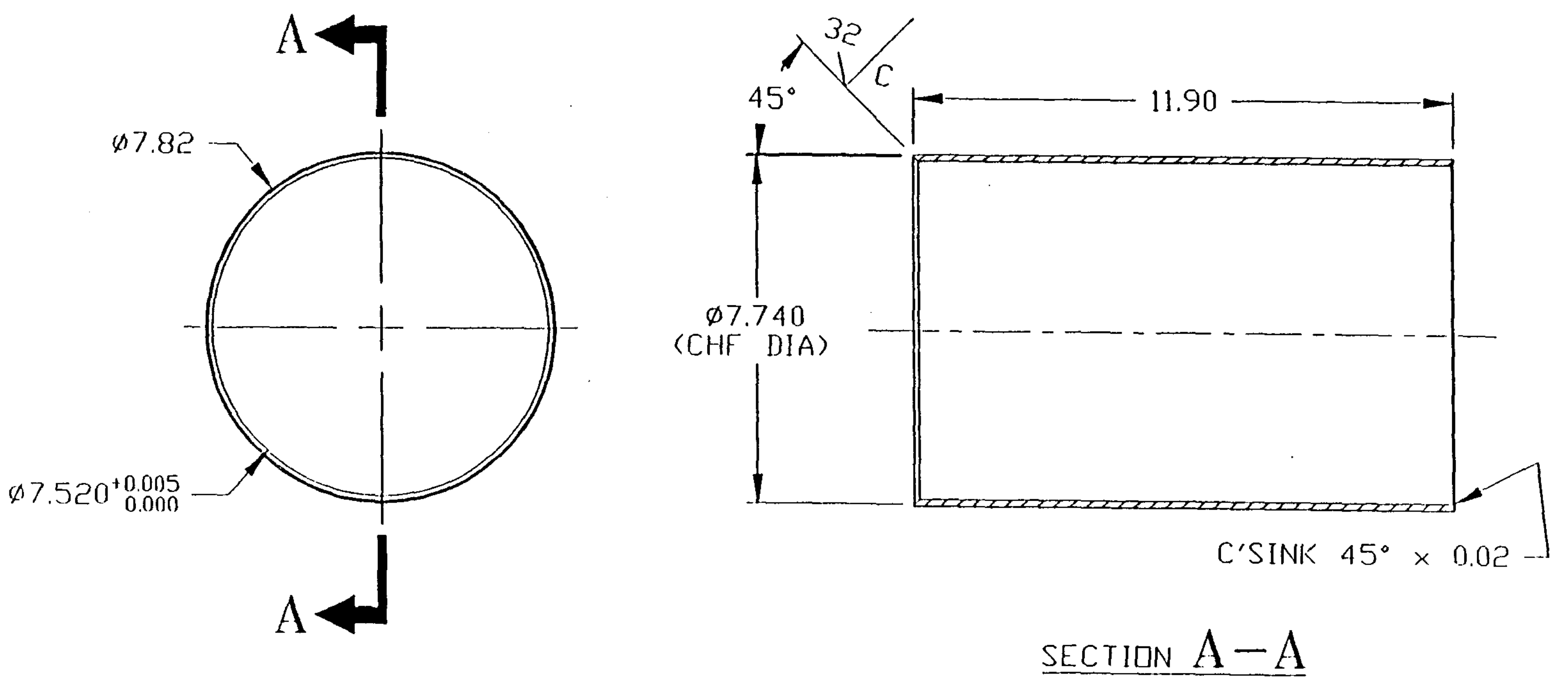
MATERIAL
OFHC COPPER

FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

VACUUM ENCLOSURE COVER FOR MASER

PROJECT	SIZE	COMPUTER FILE VACENCVR.DWG	ISSUE
1190-3	A	MASR-0132	
SCALE 1=2	DO NOT SCALE PRINT		SHEET 1 OF 2



REVISIONS

SYM	ZONE	DESCRIPTION	DATE	APPRV.

NOTES:

1. NEXT ASS'Y: MASR-0131

TOLERANCES

ENGLISH ☒ INCHES
FRAC. ±1/64
DECIMALS:
.XX ±.01
.XXX ±.005
.XXXX ± .0005

METRIC ☐ MILLIMETERS
DECIMALS:
.X ±.1
.XX±.01

ANGLES ± 1°-0'

	SIGNATURE	DATE
DRAWN	TVP	5-19-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X

MATERIAL
ALUMINUM
6061-T6

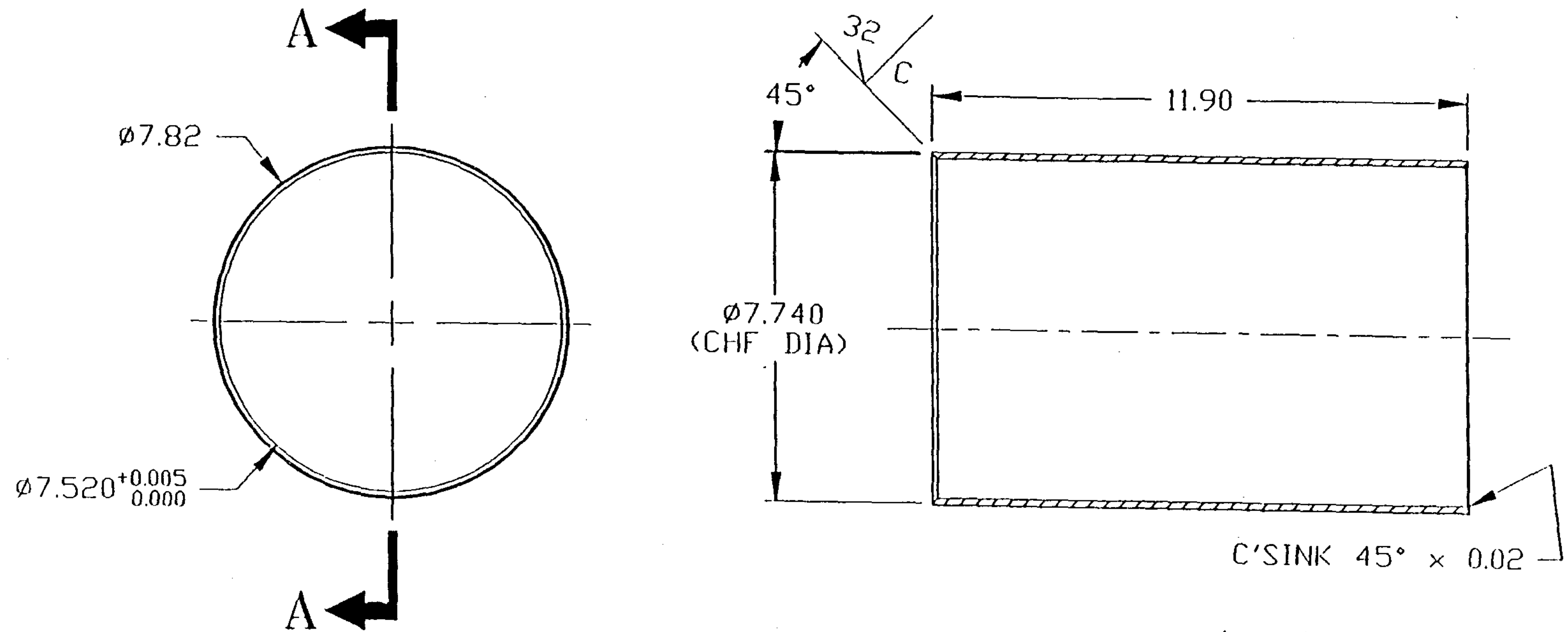
FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

VACUUM ENCLOSURE
CYLINDER
FOR MASER

PROJECT	SIZE	COMPUTER FILE VACENCYL.DWG	ISSUE
1190-3	A	MASR-0133	
SCALE 1=4	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



SECTION A–A

NOTES:

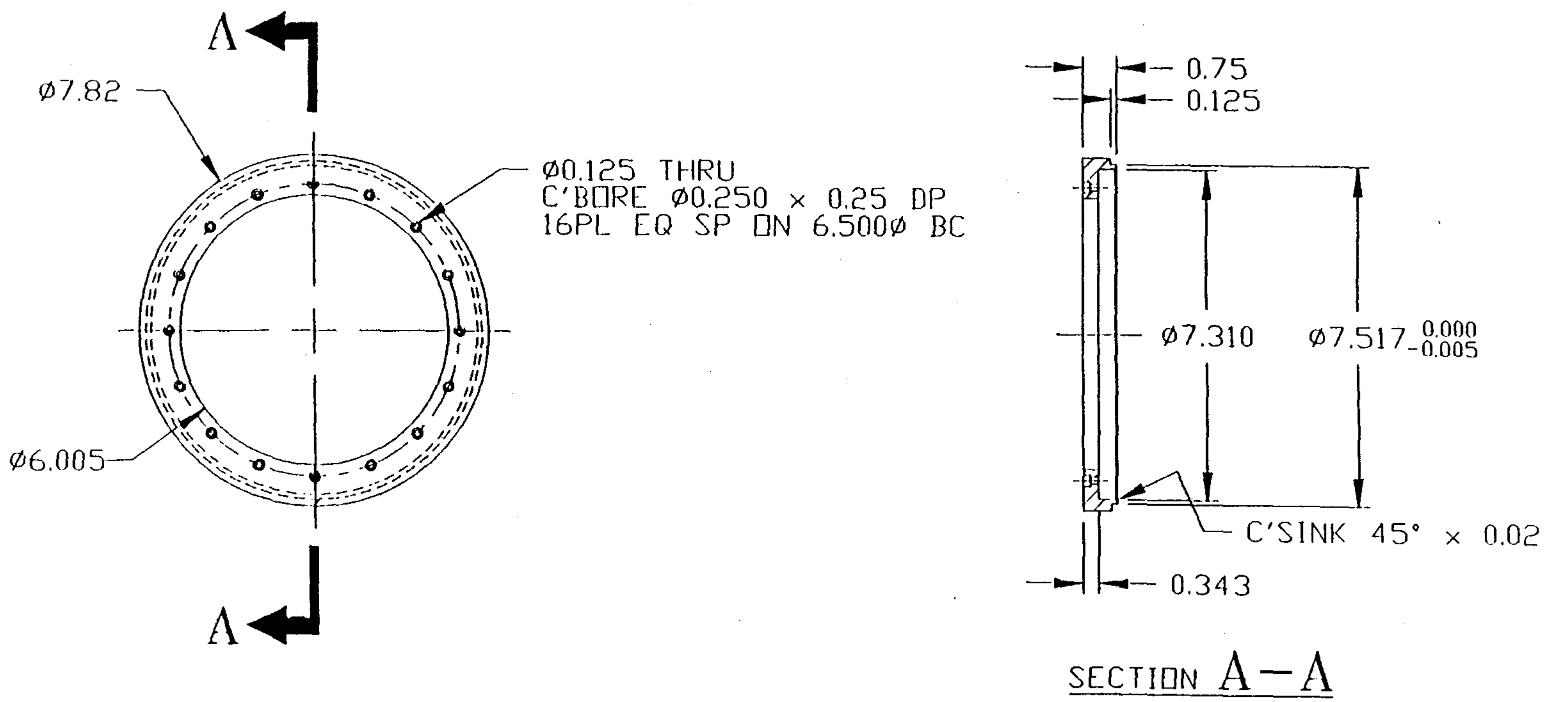
1. NEXT ASS'Y: MASR-0131

TOLERANCES				
ENGLISH ☒ INCHES	METRIC ☐ MILLIMETERS	DRAWN	TVP	5-19-94
FRAC.±1/64	DECIMALS:	CHECKED	X	X
DECIMALS:	.X ±.1	APPROVED	X	X
.XX ±.01	.XX±.01	APPROVED	X	X
.XXX ±.005		RELEASED	X	X
.XXXX ± .0005			SIGNATURE	DATE
ANGLES ± 1°-0'				
MATERIAL: ALUMINUM 6061-T6		FINISH: 32		

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

VACUUM ENCLOSURE
CYLINDER
FOR MASER

PROJECT	SIZE	COMPUTER FILE VACENCYL.DWG	ISSUE
1190-3	A	MASR-0133	
SCALE 1=4		DO NOT SCALE PRINT	SHEET 1 OF 1



NOTES:

1. NEXT ASS'Y:
   MASR-0131

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.

TOLERANCES	
ENGLISH ☒ INCHES	METRIC ☐ MILLIMETERS
FRAC. ±1/64	
DECIMALS: .XX ±.01, .XXX ±.005, .XXXX ± .0005	DECIMALS: .X ±.1, .XX±.01
ANGLES ± 1°-0'	

	SIGNATURE	DATE
DRAWN	TVP	5-19-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X

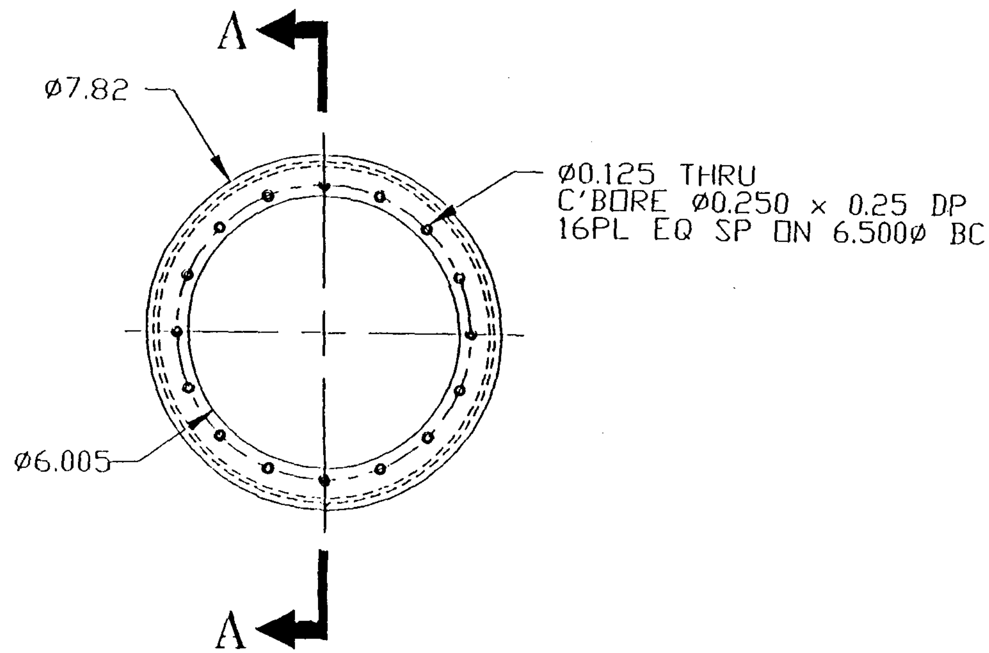
MATERIAL: ALUMINUM 6061-T6

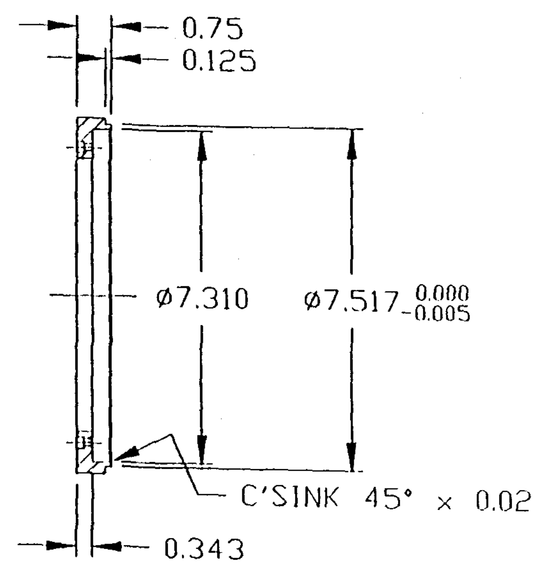
FINISH: 32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

VACUUM ENCLOSURE TOP SECTION FOR MASER

PROJECT	SIZE	COMPUTER FILE VACENTOP.DWG	ISSUE
1190-3	A	MASR-0134	
SCALE 1=4	DO NOT SCALE PRINT	SHEET 1 OF 1	





SECTION A–A

NOTES:

1. NEXT ASS'Y: MASR-0131

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.

TOLERANCES

ENGLISH ☒ INCHES	METRIC ☐ MILLIMETERS
FRAC. ±1/64	
DECIMALS:	DECIMALS:
.XX ±.01	.X ±.1
.XXX ±.005	.XX ±.01
.XXXX ± .0005	

ANGLES ± 1°-0'

DRAWN	TVP	5-19-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X
	SIGNATURE	DATE

MATERIAL: ALUMINUM 6061-T6

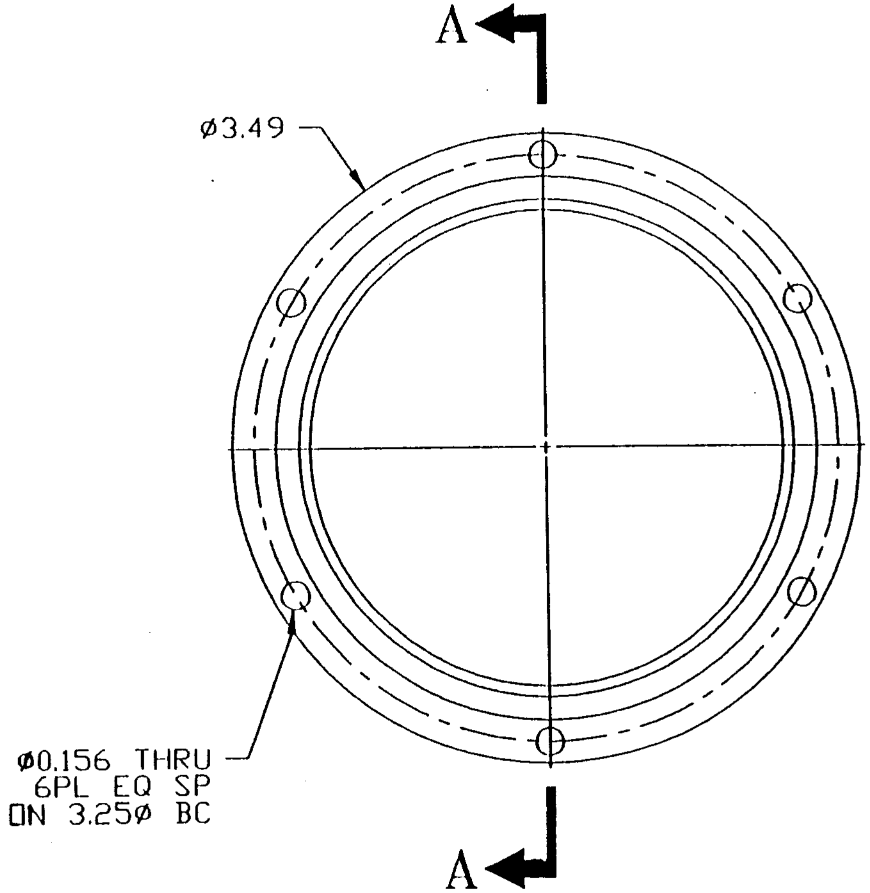
FINISH: 32

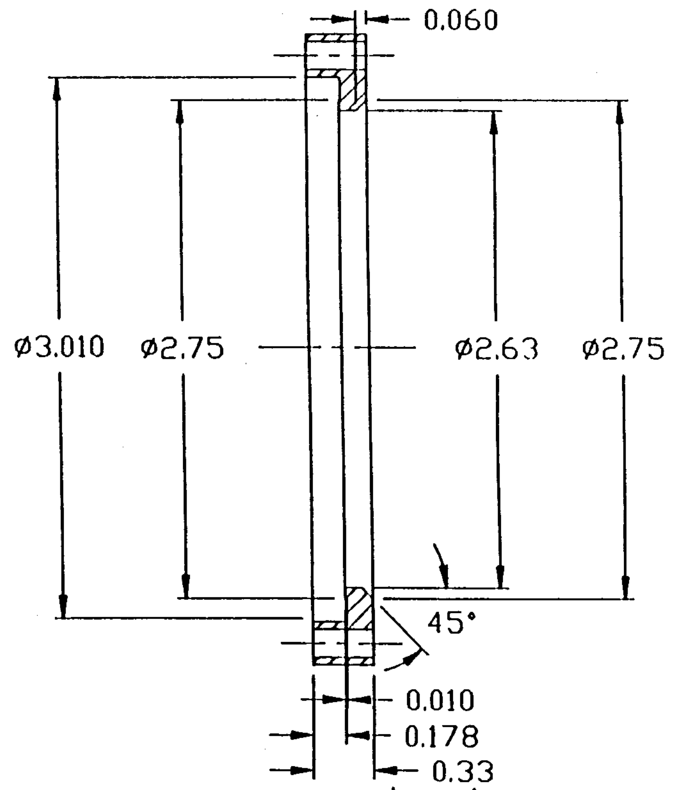
PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

VACUUM ENCLOSURE
TOP SECTION
FOR MASER

PROJECT	SIZE	COMPUTER FILE VACENTOP.DWG	ISSUE
1190-3	A	MASR-0134	
SCALE 1=4	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.





SECTION A–A

TOLERANCES
ENGLISH ☒ INCHES
FRAC.±1/64
DECIMALS:
.XX ±.01
.XXX ±.005
.XXXX ± .0005
METRIC ☐ MILLIMETERS
DECIMALS:
.X ±.1
.XX±.01
ANGLES ± 1°-0'

MATERIAL
ALUMINUM
6061-T6

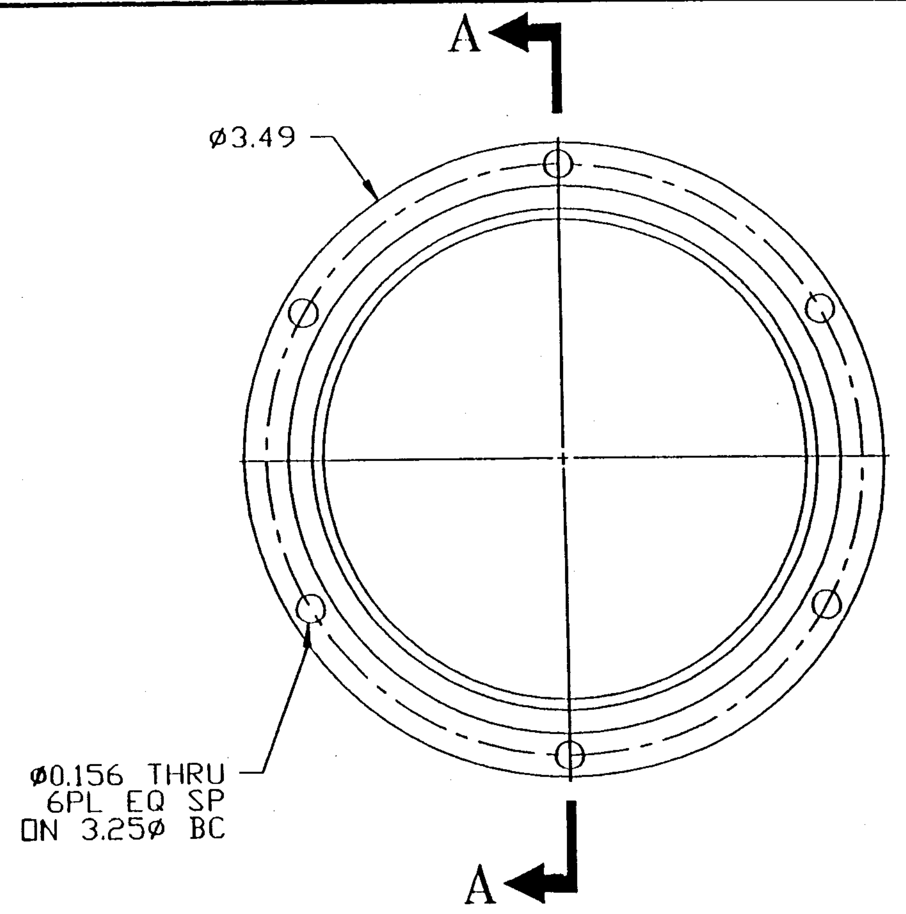
DRAWN	TVP	5-8-95
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X
	SIGNATURE	DATE

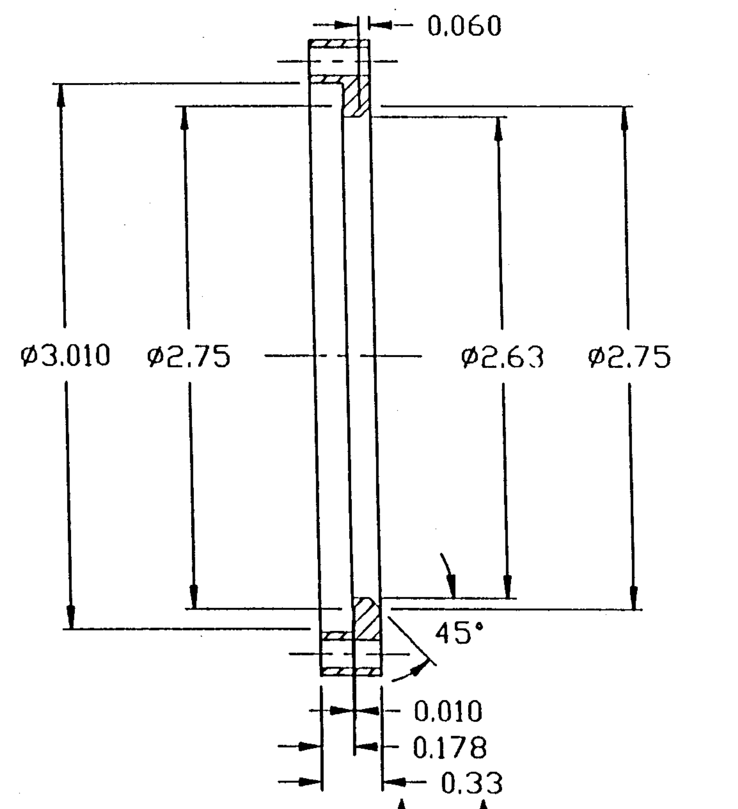
FINISH
32

PSI PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

FILLPLATE CLAMP
FOR MASER

PROJECT	SIZE	COMPUTER FILE FILCLMP.DWG	ISSUE
1190-3	A	MASR-0150	
SCALE 1 = 1	DO NOT SCALE PRINT	SHEET 1 OF 1	





SECTION A—A

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.

TOLERANCES

ENGLISH ☒	METRIC ☐
INCHES	MILLIMETERS
FRAC.±1/64	DECIMALS:
DECIMALS:	.X ±.1
.XX ±.01	.XX±.01
.XXX ±.005	
.XXXX ± .0005	

ANGLES ± 1°-0'

MATERIAL
ALUMINUM
6061-T6

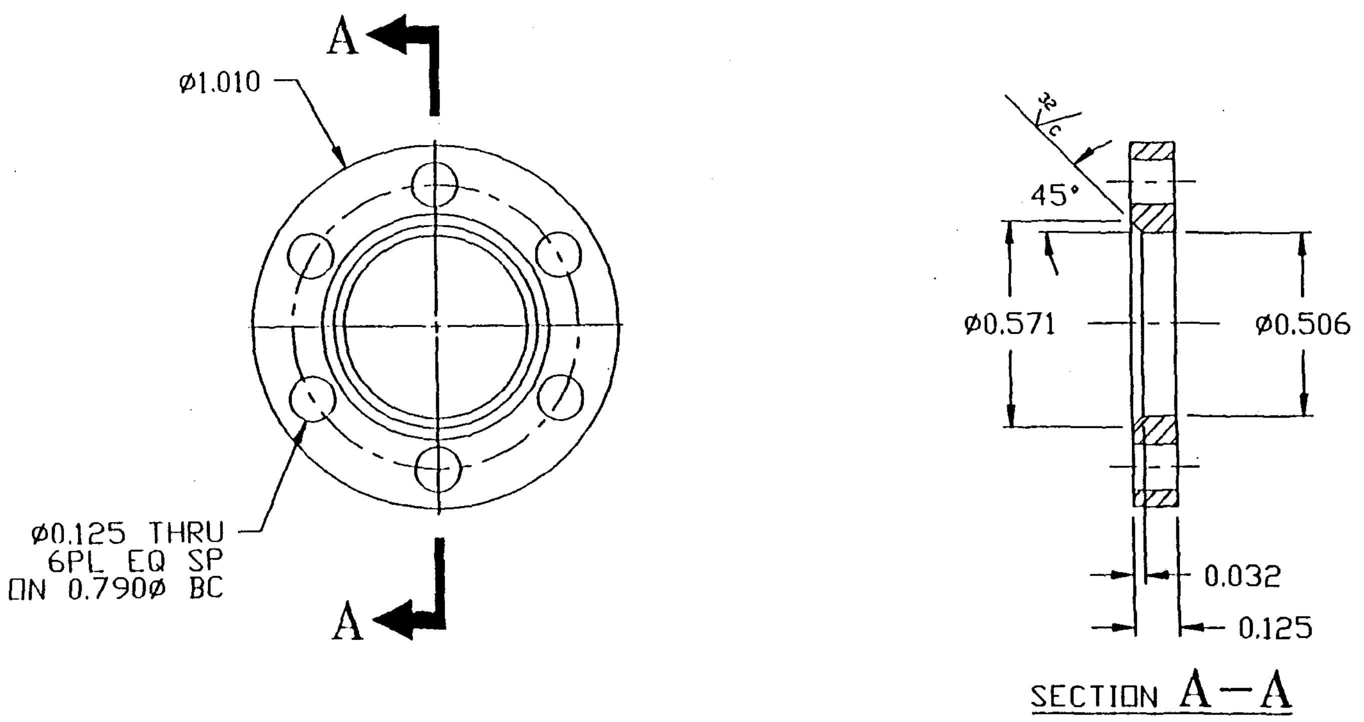
DRAWN	TVP	5-8-95
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X
	SIGNATURE	DATE

FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

FILLPLATE CLAMP
FOR MASER

PROJECT	SIZE	COMPUTER FILE FILCLMP.DWG	ISSUE
1190-3	A	MASR-0150	
SCALE 1 = 1	DO NOT SCALE PRINT	SHEET 1 OF 1	



REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.

TOLERANCES

ENGLISH ☒ INCHES — FRAC. ±1/64; DECIMALS: .XX ±.01, .XXX ±.005, .XXXX ± .0005

METRIC ☐ MILLIMETERS — DECIMALS: .X ±.1, .XX±.01

ANGLES ± 1°-0'

	SIGNATURE	DATE
DRAWN	TVP	5-8-95
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X

MATERIAL ALUMINUM 6061-T6

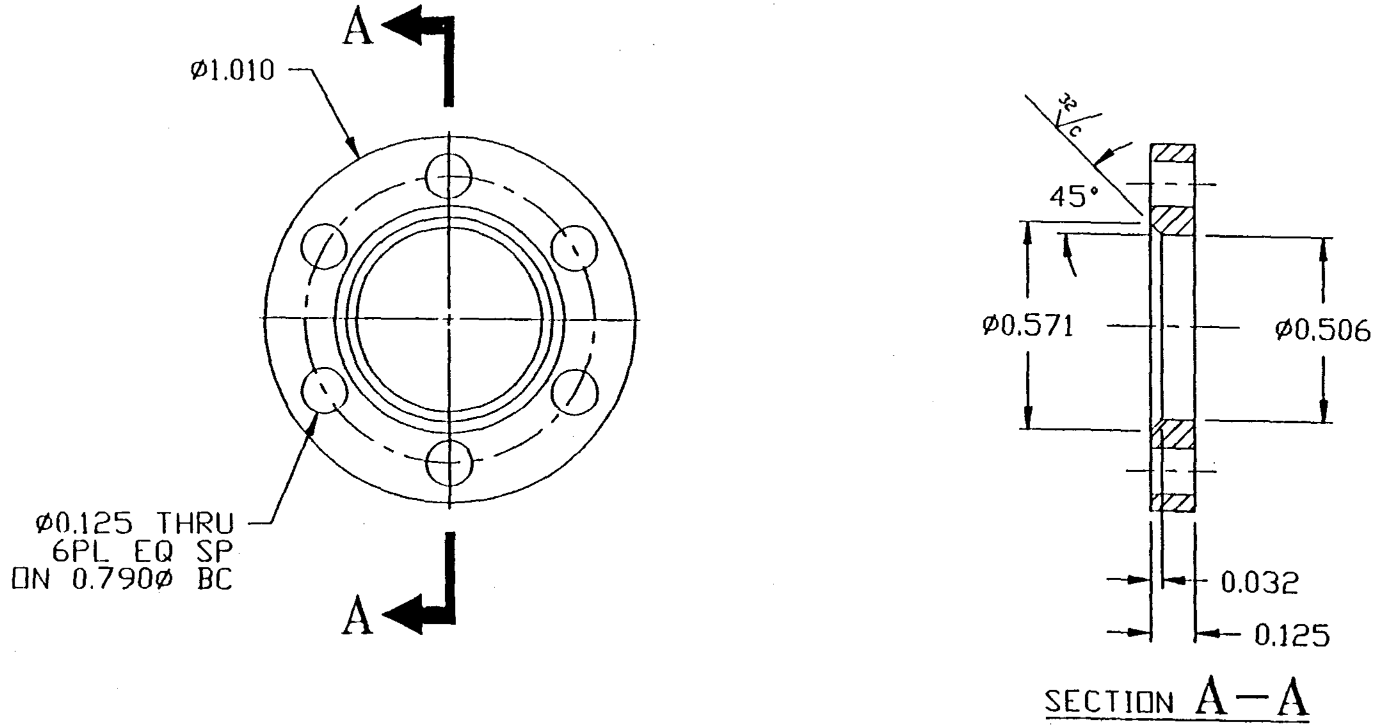
FINISH 32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

FILLPLATE COLLAR
FOR MASER

PROJECT	SIZE	COMPUTER FILE FLPLTCLR.DWG	ISSUE
1190-3	A	MASR-0151	
SCALE 2 = 1	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



TOLERANCES

ENGLISH ☒ INCHES
FRAC.±1/64
DECIMALS:
.XX ±.01
.XXX ±.005
.XXXX ± .0005

METRIC ☐ MILLIMETERS
DECIMALS:
.X ±.1
.XX±.01

ANGLES ± 1°-0'

	SIGNATURE	DATE
DRAWN	TVP	5-8-95
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X

MATERIAL
ALUMINUM
6061-T6

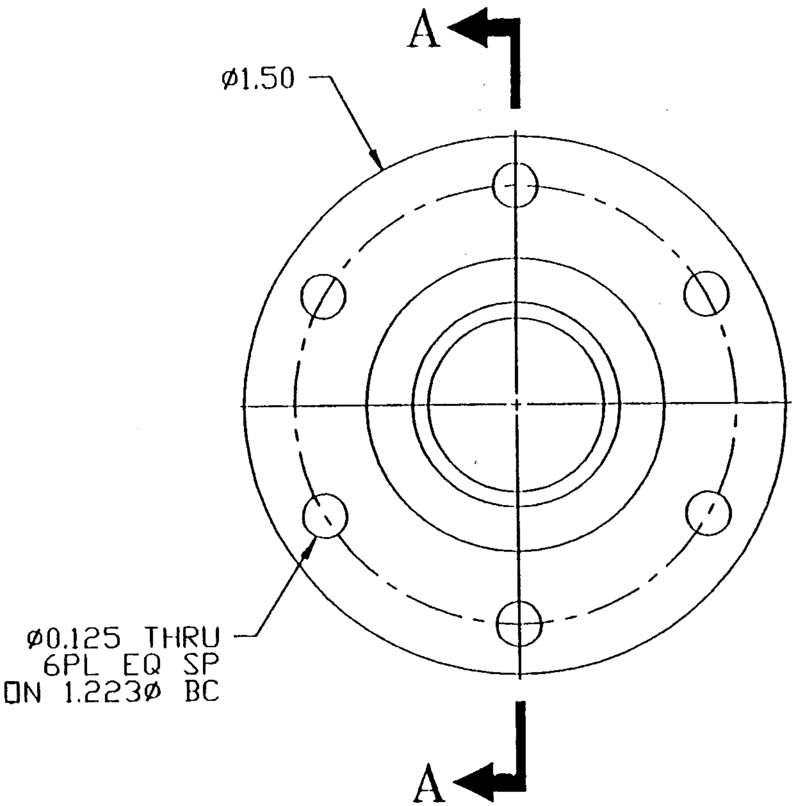
FINISH
32

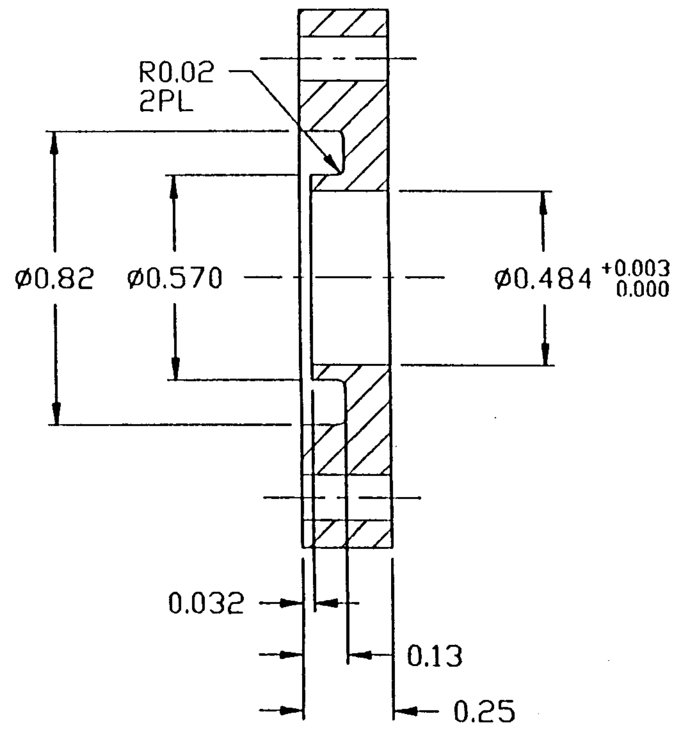
PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

FILLPLATE COLLAR
FOR MASER

PROJECT	SIZE	COMPUTER FILE FLPLTCLR.DWG	ISSUE
1190-3	A	MASR-0151	
SCALE 2 = 1	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.





SECTION A–A

TOLERANCES	
ENGLISH ☒	METRIC ☐
INCHES	MILLIMETERS
FRAC.±1/64	DECIMALS:
DECIMALS:	.X ±.1
.XX ±.01	.XX±.01
.XXX ±.005	
.XXXX ± .0005	
ANGLES ± 1°-0′	

MATERIAL
SS
304

DRAWN	TVP	5-8-95
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X
	SIGNATURE	DATE

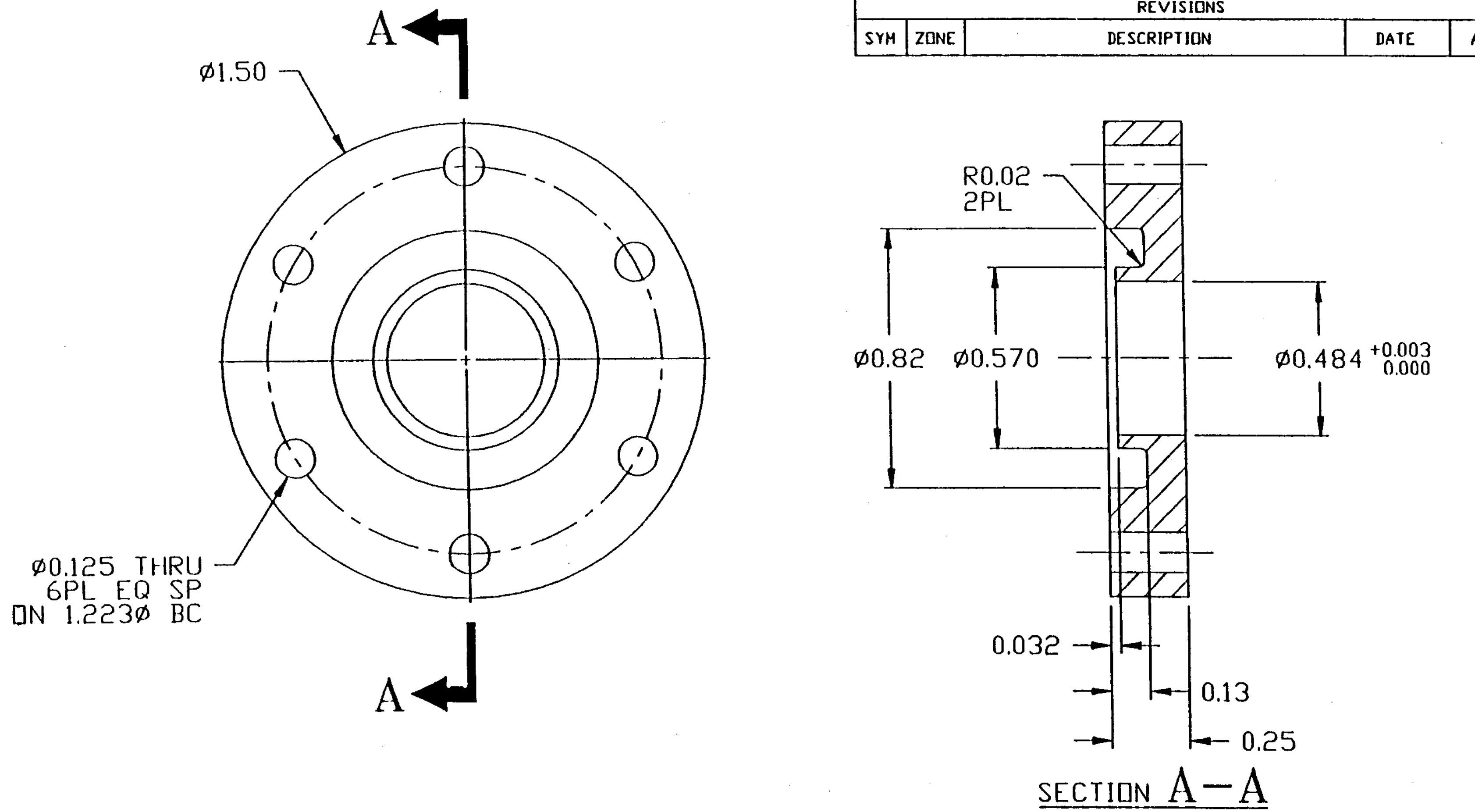
FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

LN2 FLANGE
FOR MASER

PROJECT	SIZE	COMPUTER FILE LN2FLNG.DWG	ISSUE
1190-3	A	MASR-0152	
SCALE 2 = 1	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



TOLERANCES	
ENGLISH ☒	METRIC ☐
INCHES	MILLIMETERS
FRAC.±1/64	DECIMALS:
DECIMALS:	.X ±.1
.XX ±.01	.XX±.01
.XXX ±.005	
.XXXX ± .0005	
ANGLES ± 1°-0′	

	SIGNATURE	DATE
DRAWN	TVP	5-8-95
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X

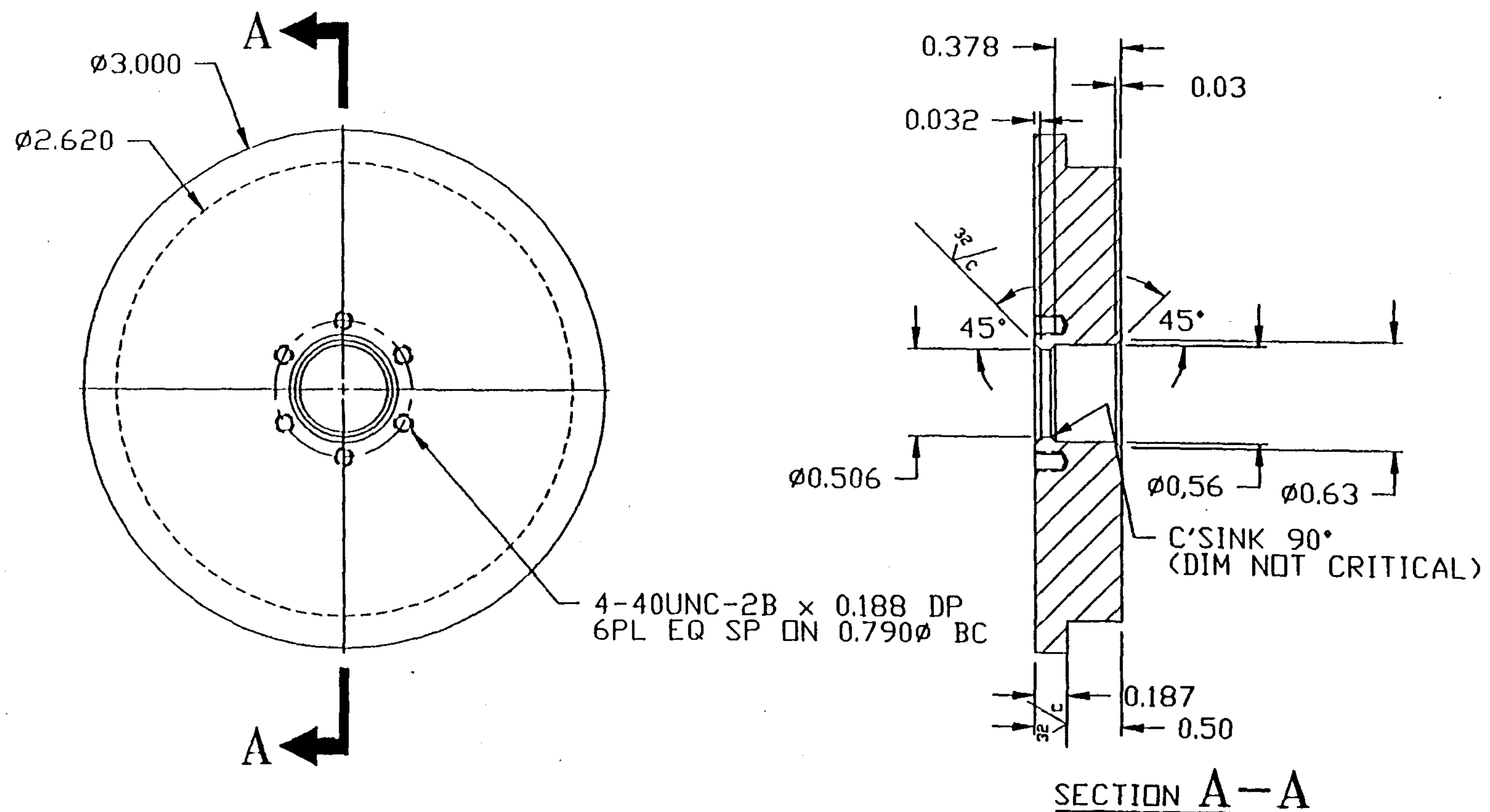
MATERIAL
SS
304

FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

LN2 FLANGE
FOR MASER

PROJECT	SIZE	COMPUTER FILE LN2FLNG.DWG	ISSUE
1190-3	A	MASR-0152	
SCALE 2 = 1	DO NOT SCALE PRINT	SHEET 1 OF 1	



REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.

TOLERANCES	
ENGLISH ☒ INCHES	METRIC ☐ MILLIMETERS
FRAC.±1/64	DECIMALS:
DECIMALS:	.X ±.1
.XX ±.01	.XX±.01
.XXX ±.005	
.XXXX ± .0005	
ANGLES ± 1°-0'	

	SIGNATURE	DATE
DRAWN	TVP	5-12-95
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X

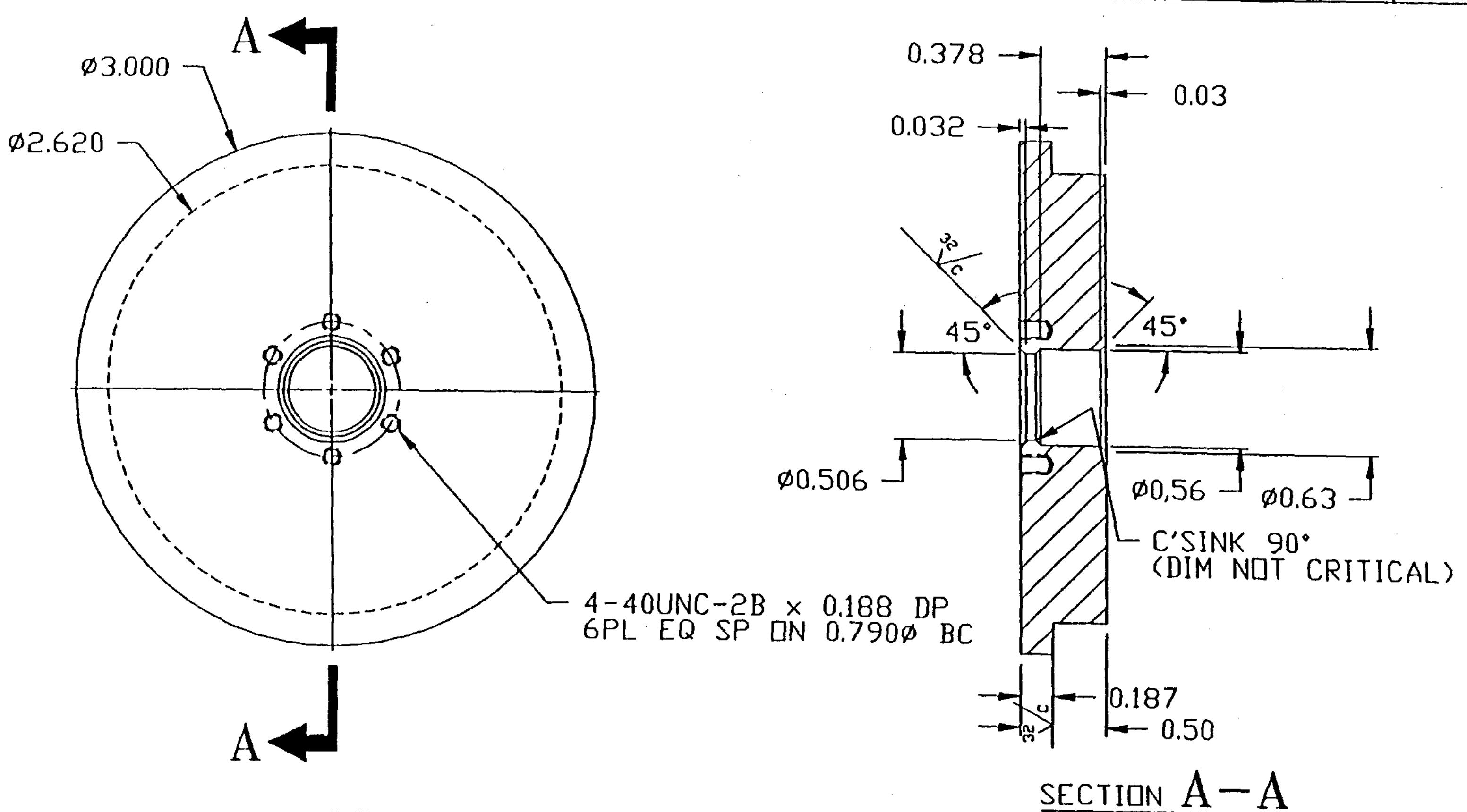
MATERIAL
ALUMINUM
6061-T6

FINISH
32

PSI PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

FILL PLATE
FOR MASER

PROJECT	SIZE	COMPUTER FILE FILPLAT.DWG	ISSUE
1190-3	A	MASR-0153	
SCALE 1 = 1	DO NOT SCALE PRINT	SHEET 1 OF 1	



REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.

DRAWN	TVP	5-12-95
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X
	SIGNATURE	DATE

TOLERANCES

ENGLISH	METRIC
☒ INCHES	☐ MILLIMETERS
FRAC.±1/64	DECIMALS:
DECIMALS:	.X ±.1
.XX ±.01	.XX±.01
.XXX ±.005	
.XXXX ± .0005	

ANGLES ± 1°-0'

MATERIAL
ALUMINUM
6061-T6

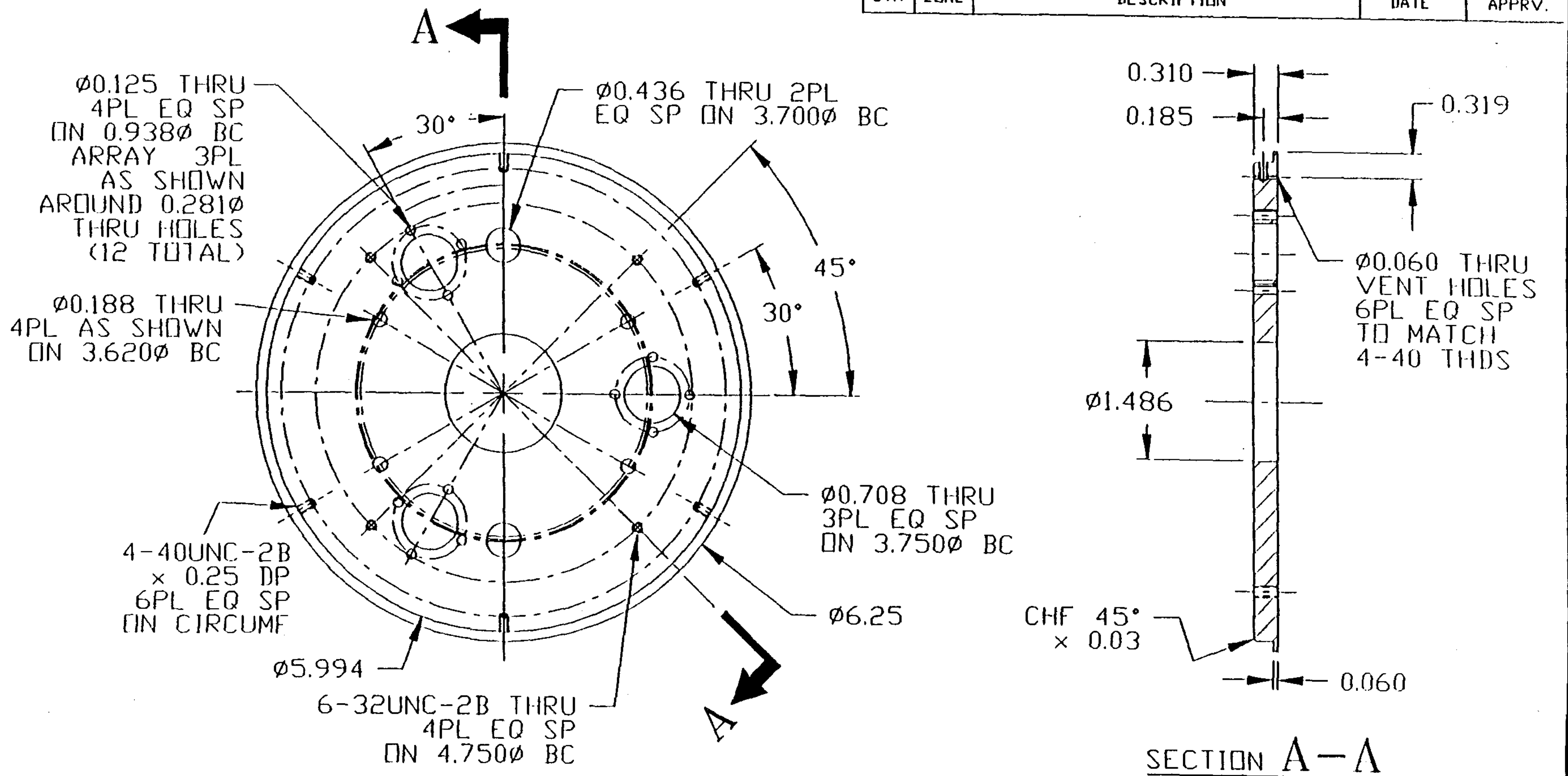
FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

FILL PLATE
FOR MASER

PROJECT	SIZE	COMPUTER FILE FILPLAT.DWG	ISSUE
1190-3	A	MASR-0153	
SCALE 1 = 1	DO NOT SCALE PRINT	SHEET 1 OF 1	

REVISIONS				
SYM	ZONE	DESCRIPTION	DATE	APPRV.



SECTION A—A

TOLERANCES	
ENGLISH ☒ INCHES	METRIC ☐ MILLIMETERS
FRAC.±1/64	
DECIMALS: .XX ±.01 .XXX ±.005 .XXXX ± .0005	DECIMALS: .X ±.1 .XX±.01
ANGLES ± 1°-0'	

DRAWN	TVP	6-9-94
CHECKED	X	X
APPROVED	X	X
APPROVED	X	X
RELEASED	X	X
	SIGNATURE	DATE

MATERIAL
ALUMINUM
6061-T6

FINISH
32

PHYSICAL SCIENCES, INC.
635 SLATERS LANE G-101
ALEXANDRIA, VA 22314

OUTER SHIELD
COVER
FOR MASER

PROJECT	SIZE	COMPUTER FILE OTRSHCVR.DWG	ISSUE
1190-3	A	MASR-0121	
SCALE 1=2	DO NOT SCALE PRINT	SHEET 1 OF 1	